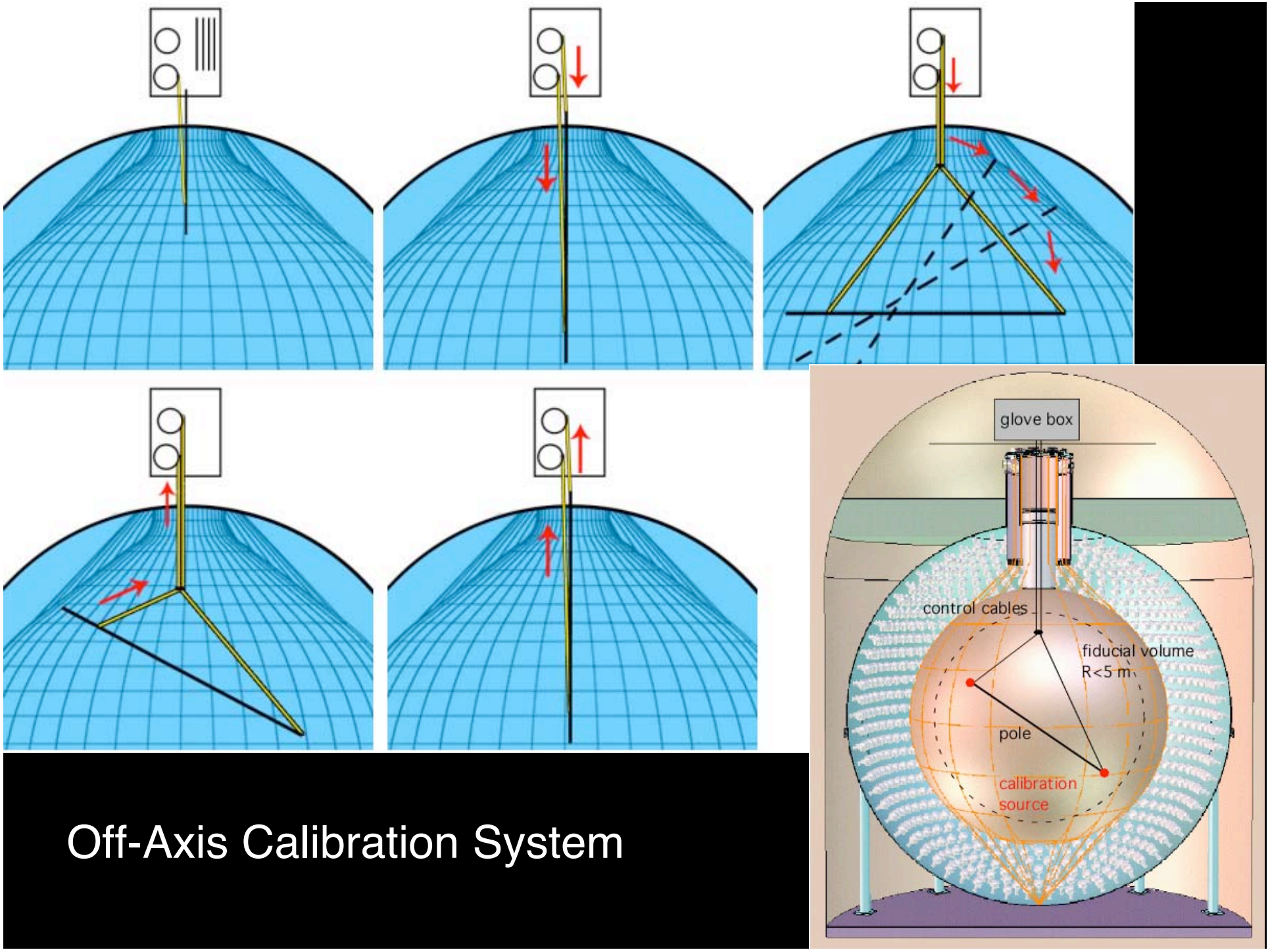
The KamLAND Off-Axis Calibration System

Karsten Heeger
LBNL

4π Group

http://kmheeger.lbl.gov/kamland/4pi/

S. Abbott
B. Berger
P. Decowski
D. Dwyer
S.J. Freedman
B. Fujikawa
M. Galloway
F. Gray
K.M. Heeger
J. Meyer
J. Learned
K.-B. Luk
Y. Minamihara
B. Perry
M. Rosen
H. Steiner
D, Syversryd
T. Walker
L. Winslow



Off-Axis Calibration System

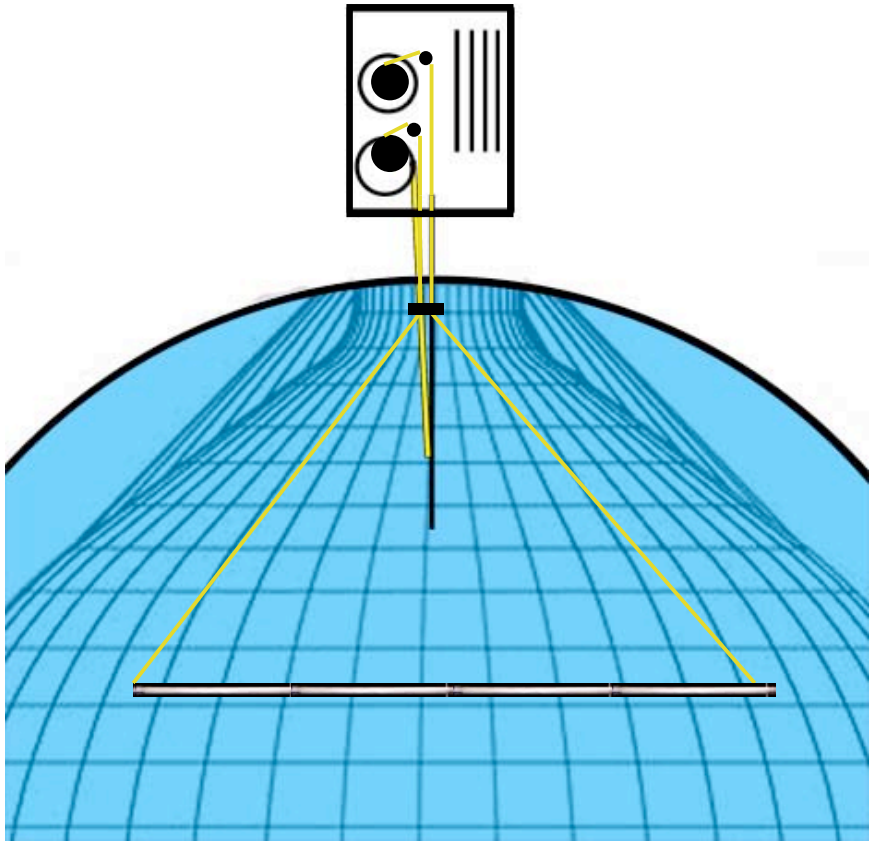
Methods of Deployment

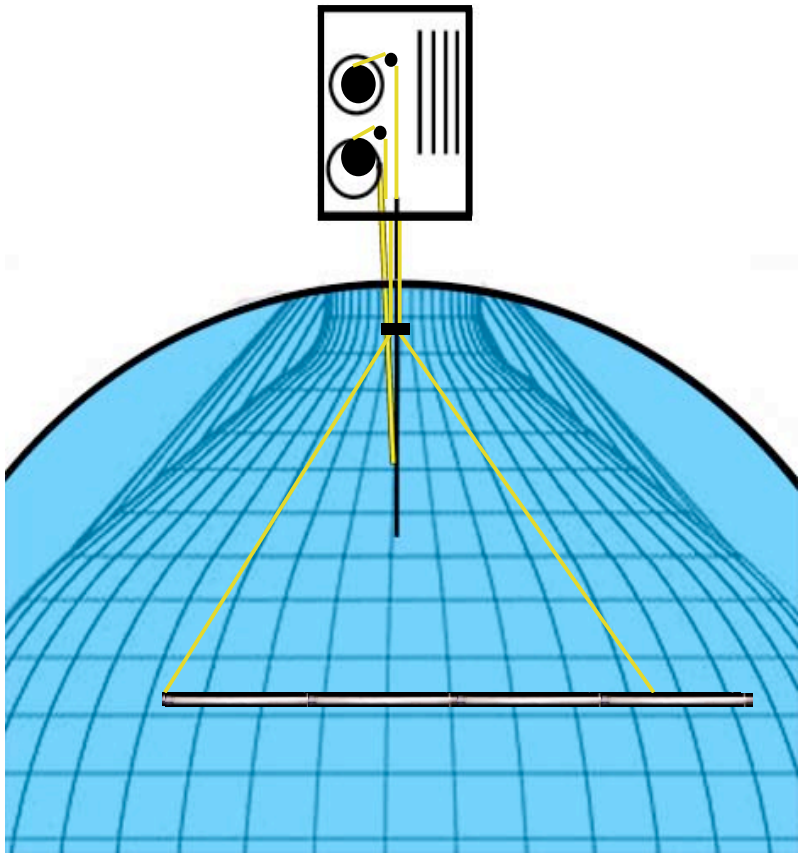
Symmetric Deployment

- Simplest

Asymmetric Deployment

- Counter weights in last pole segment
- Increases radial reach





Off-Axis Calibration System

I. Hardware

Glovebox System and
Deployment Hardware

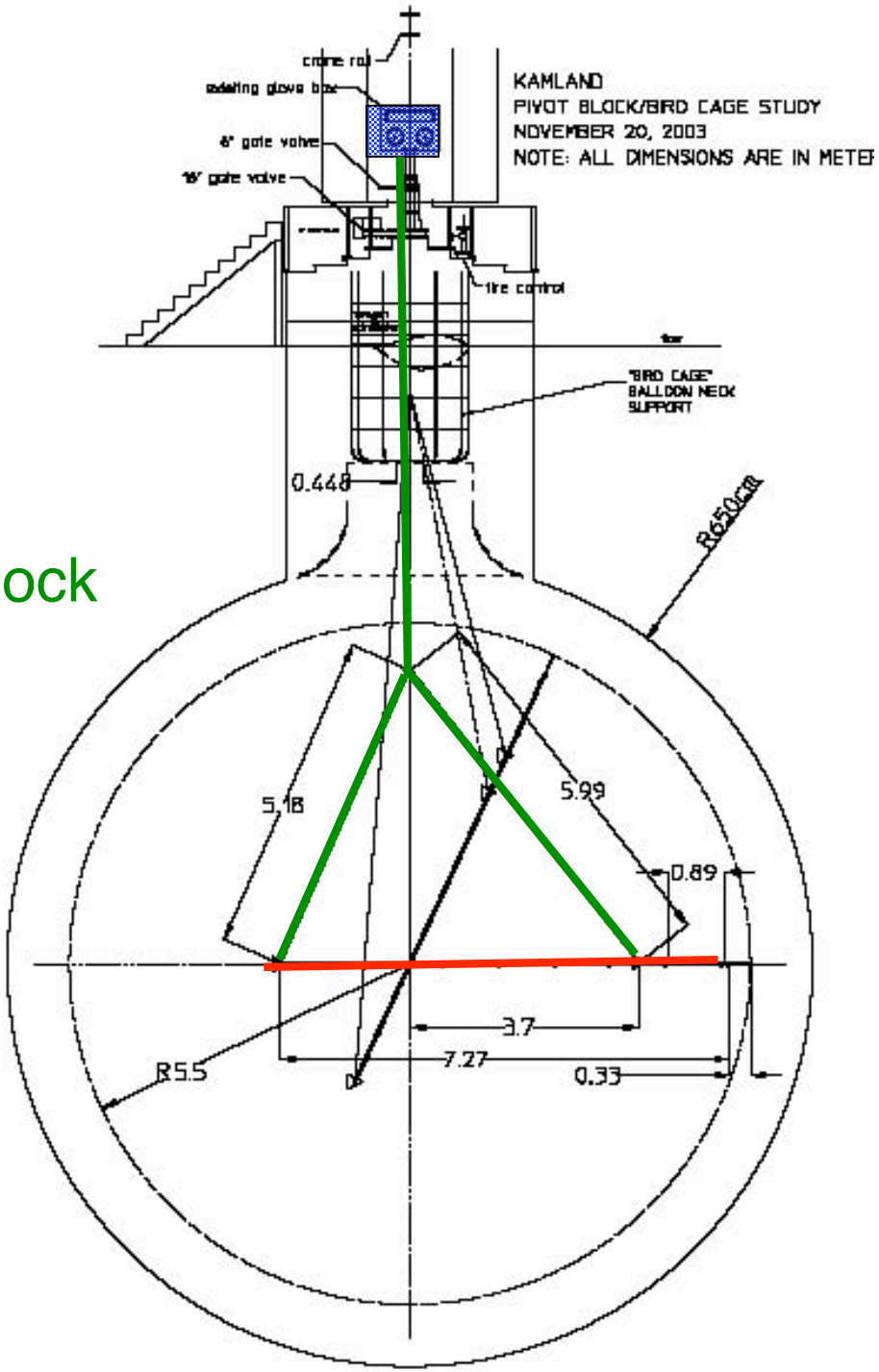
Control Cable + Pivot Block

Calibration Pole

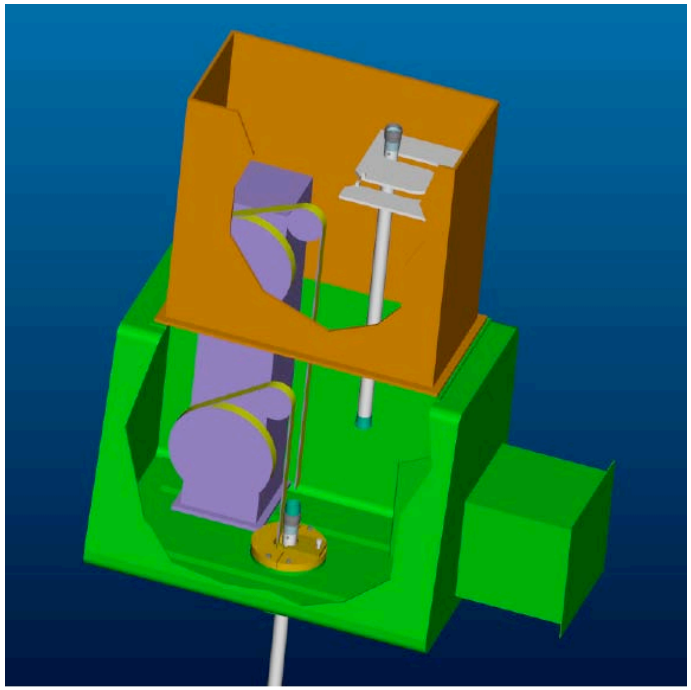
II. System Control Software

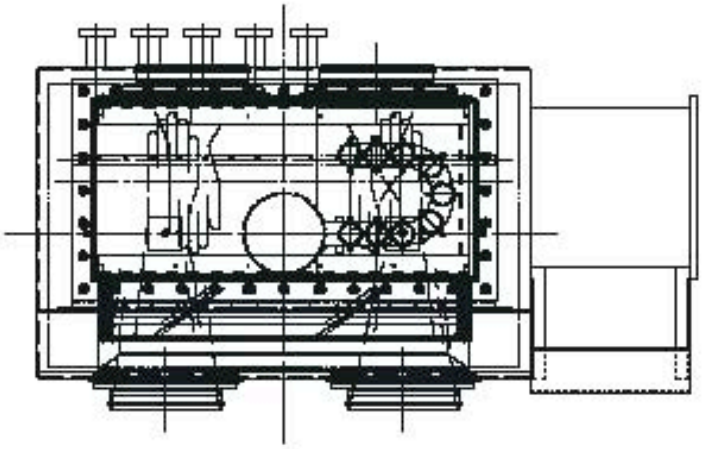
→ Fred Gray

III. Position Reconstruction

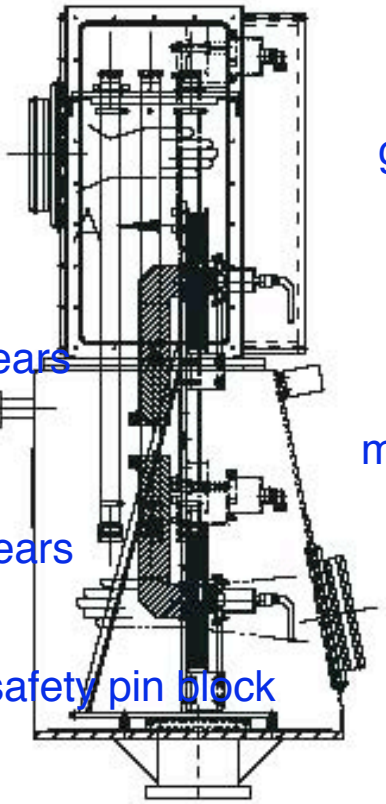


Glovebox System and Deployment Hardware





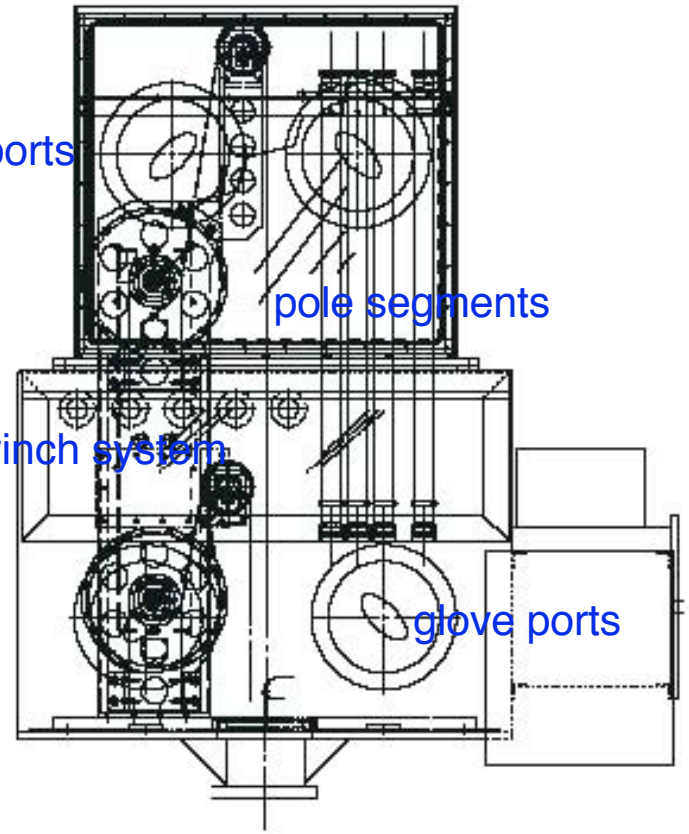
glovebox extension - penthouse



motors + gears

motors + gears

safety pin block

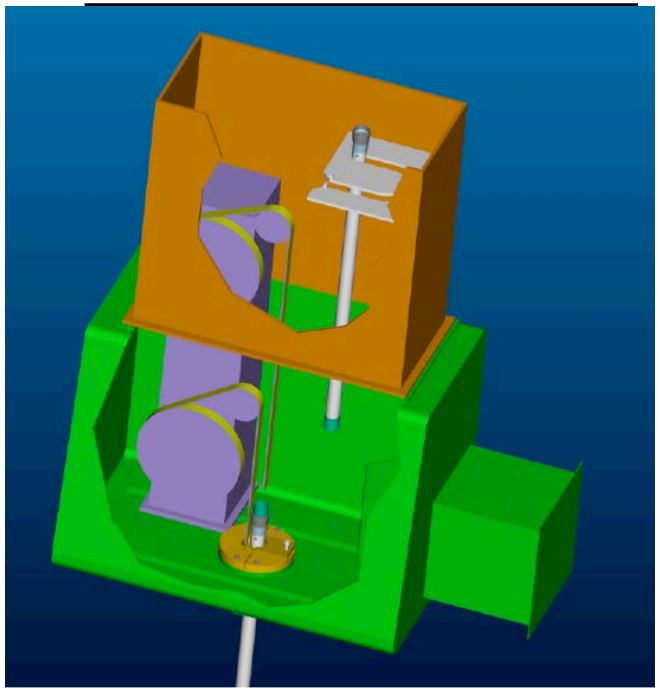


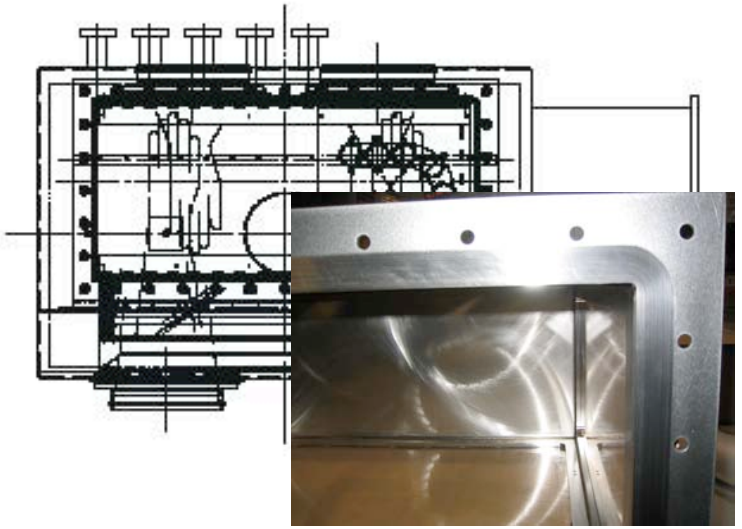
glove ports

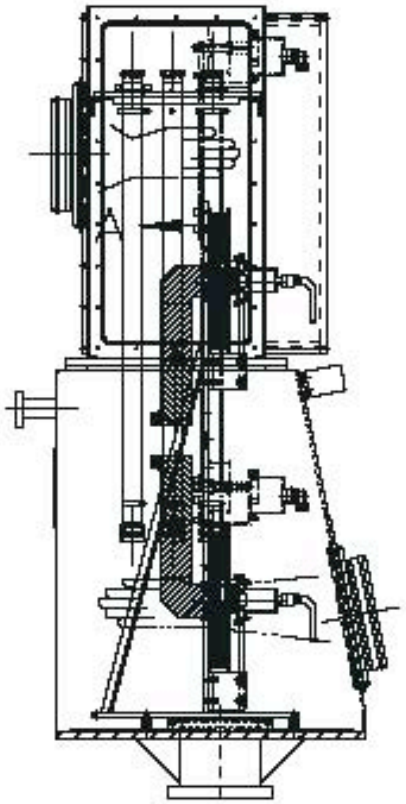
pole segments

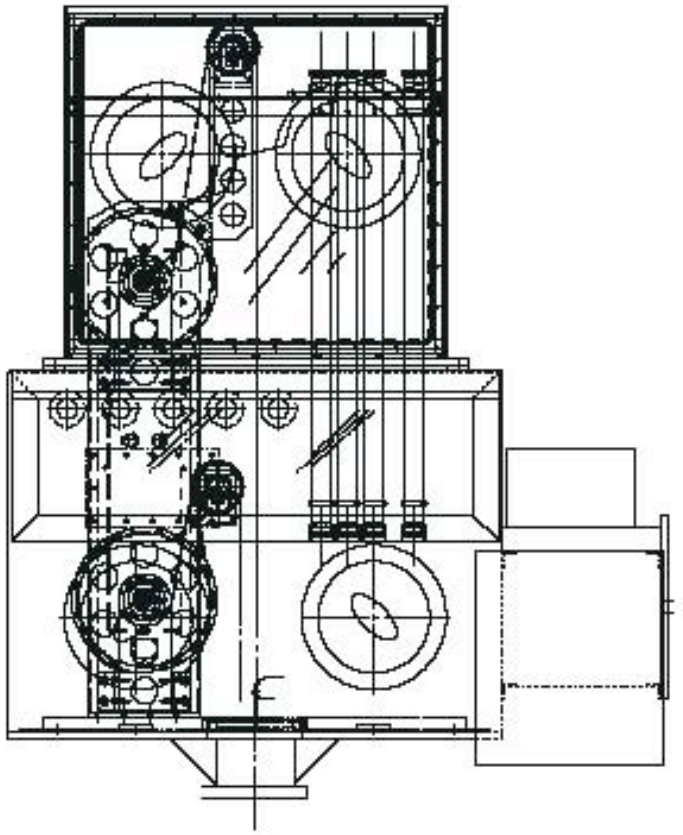
motor winch system

glove ports



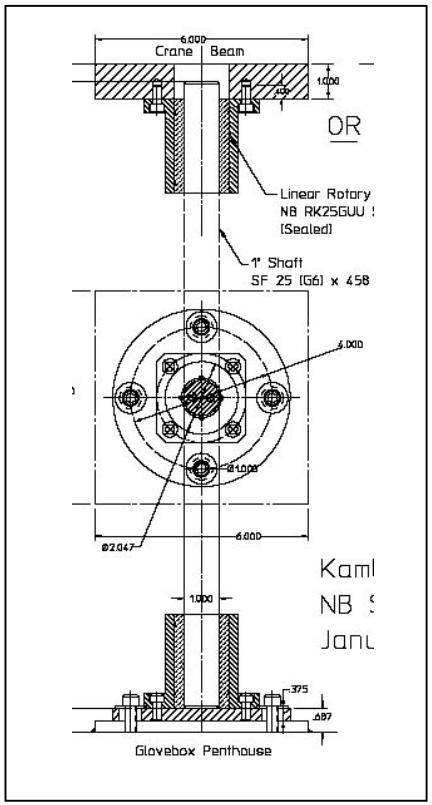


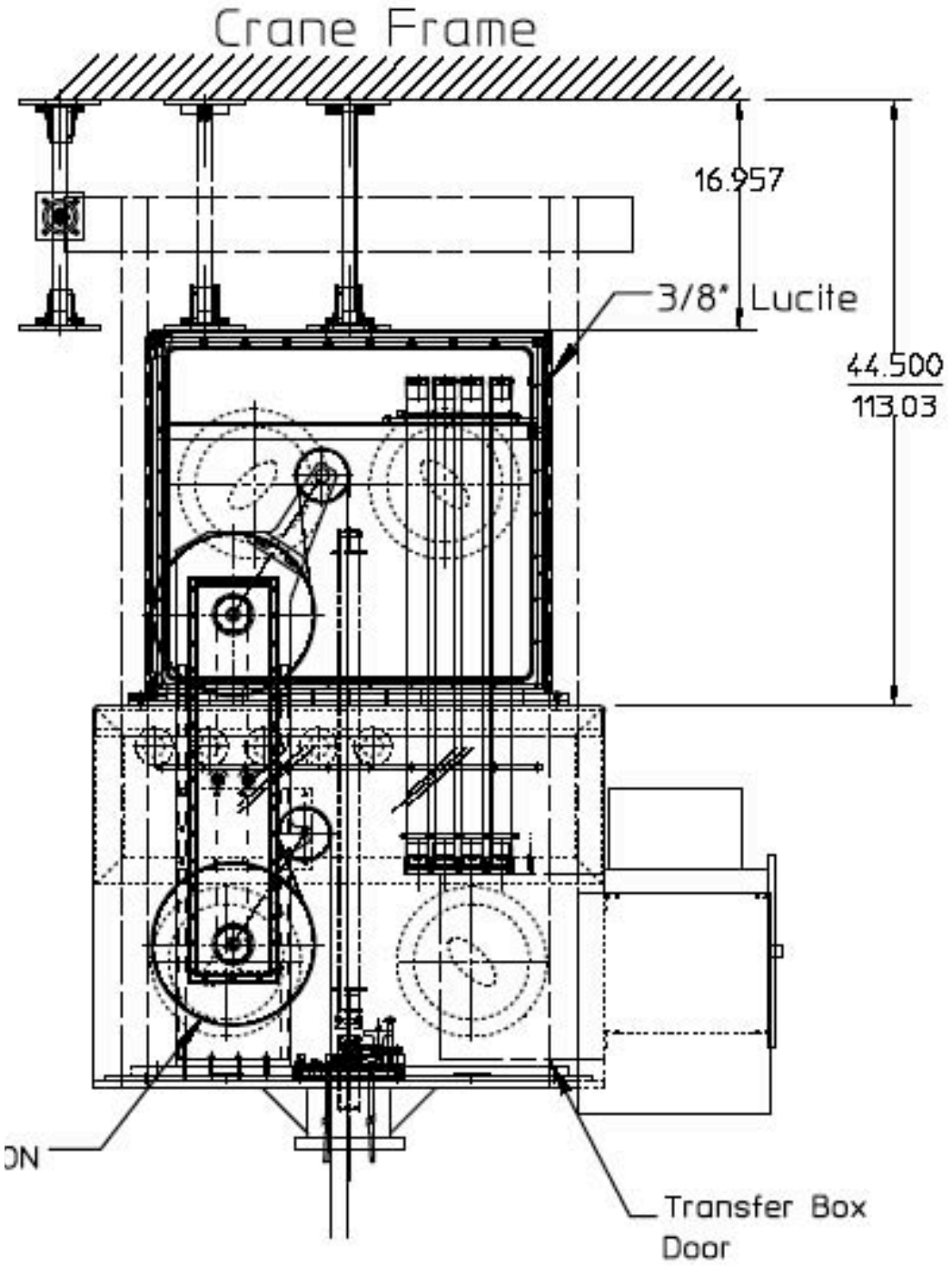




Kasten Heeger for 4pi Group

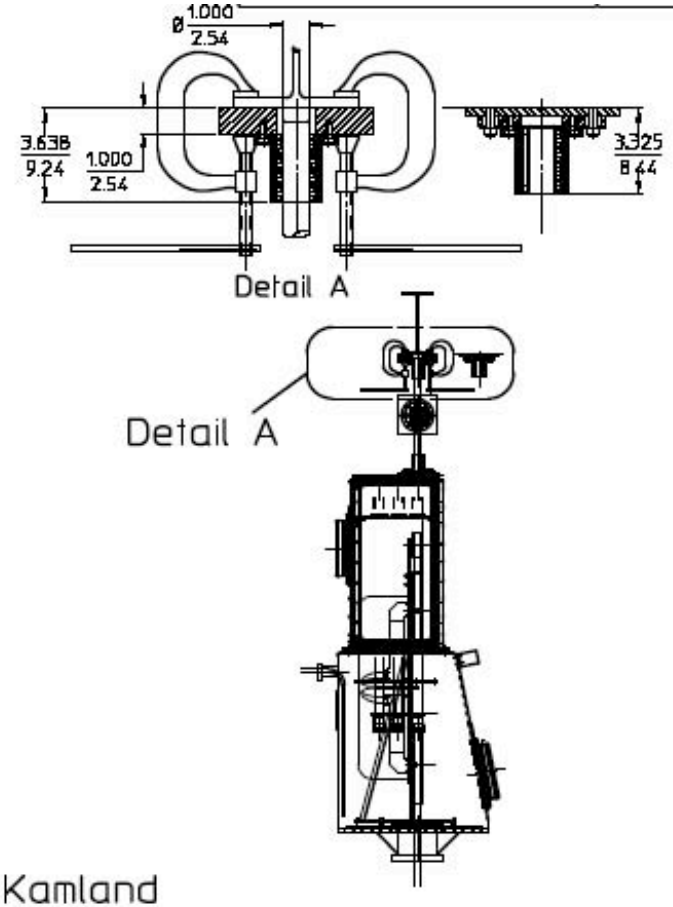
Glovebox Axial Support





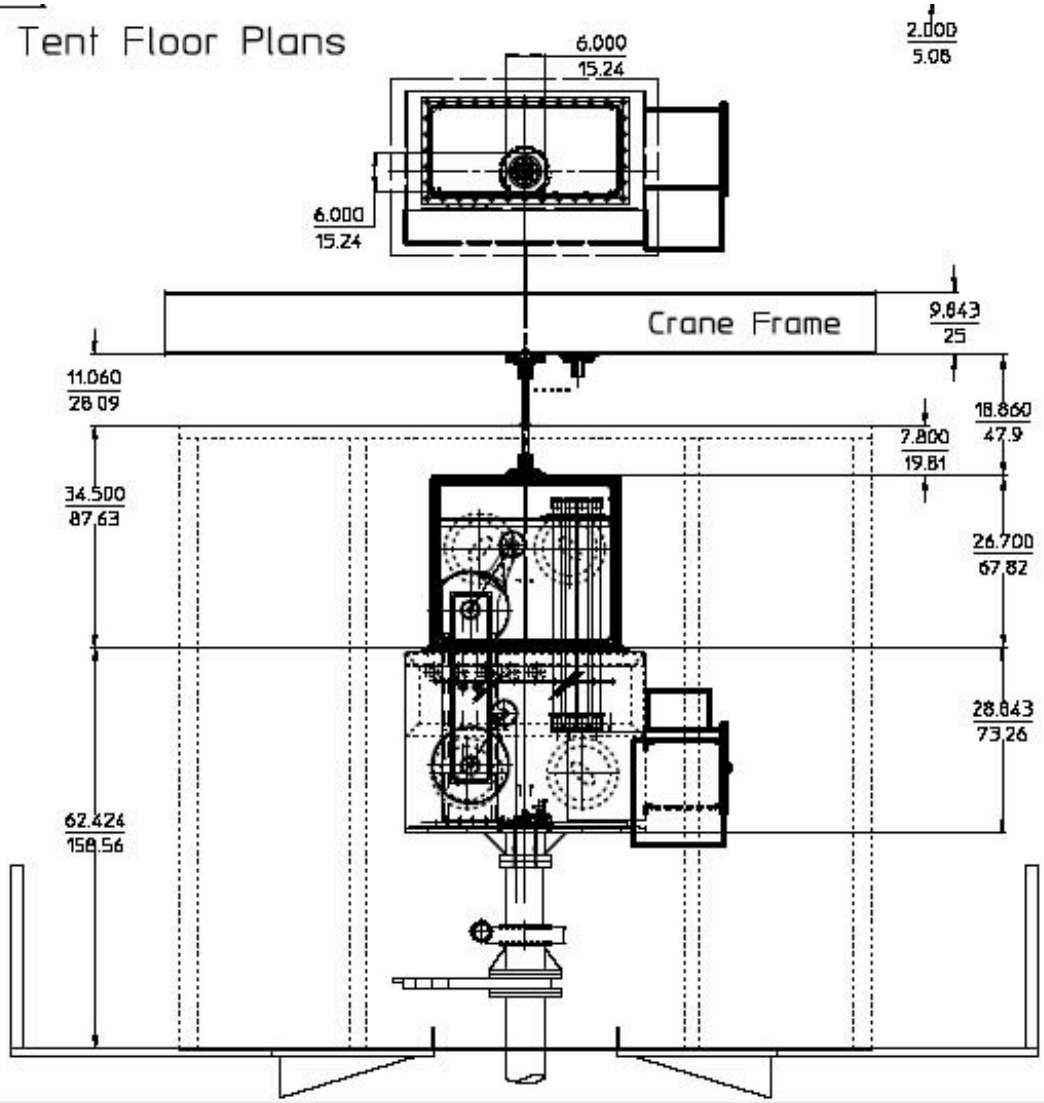
- provides axial stability
- allows system to rotate
- avoids future problems with rotary stage

Glovebox Axial Support

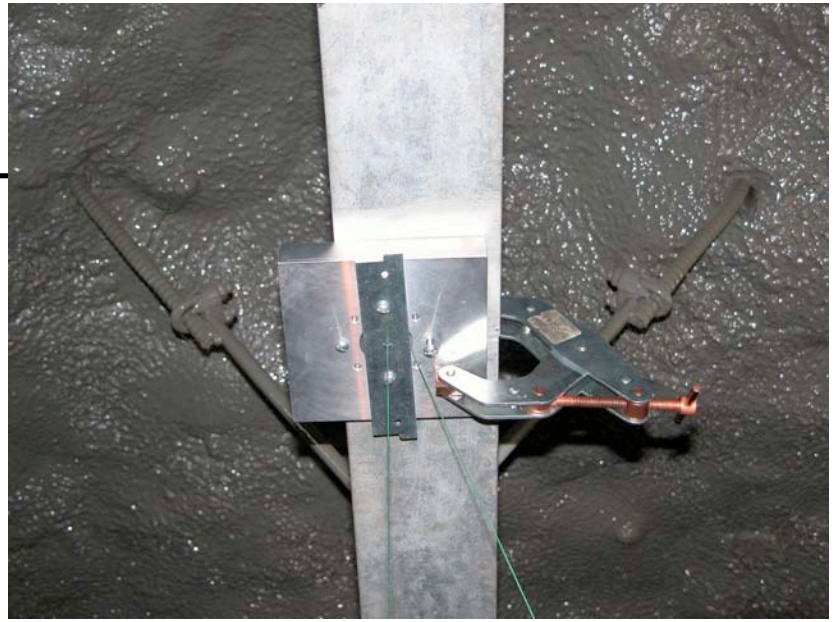


Kamland
Glovebox Support Bearing Layout
January 20, 2004

Note: All dimensions are in inches over centimeters.



Glovebox Preparations in Feb 2004

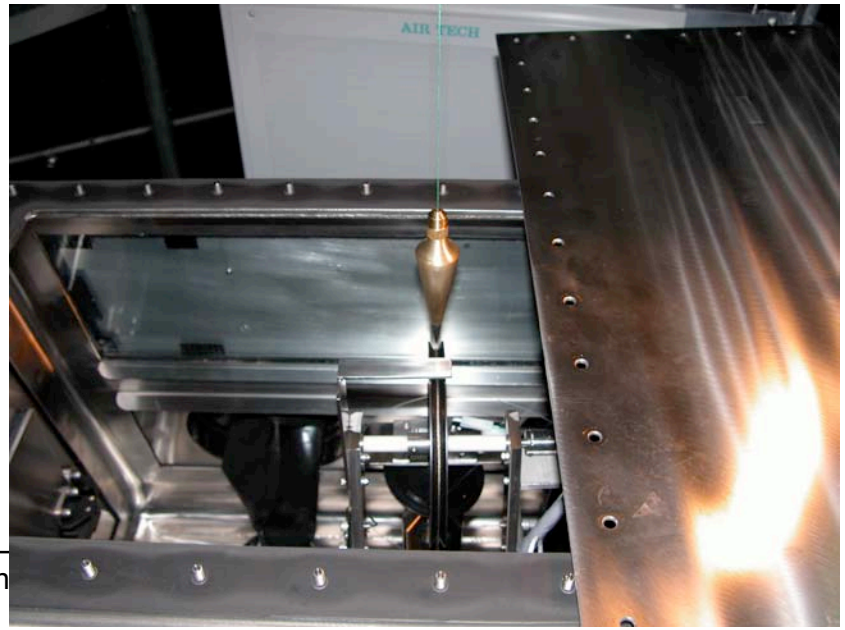


- Installed and centered I-beam plate for axial glovebox support.

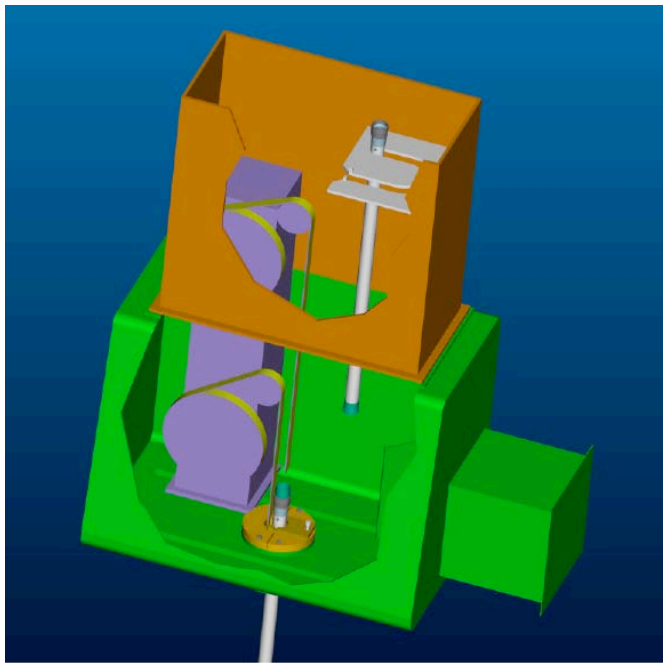
→ *Now have permanent detector center mark on I-beam.*

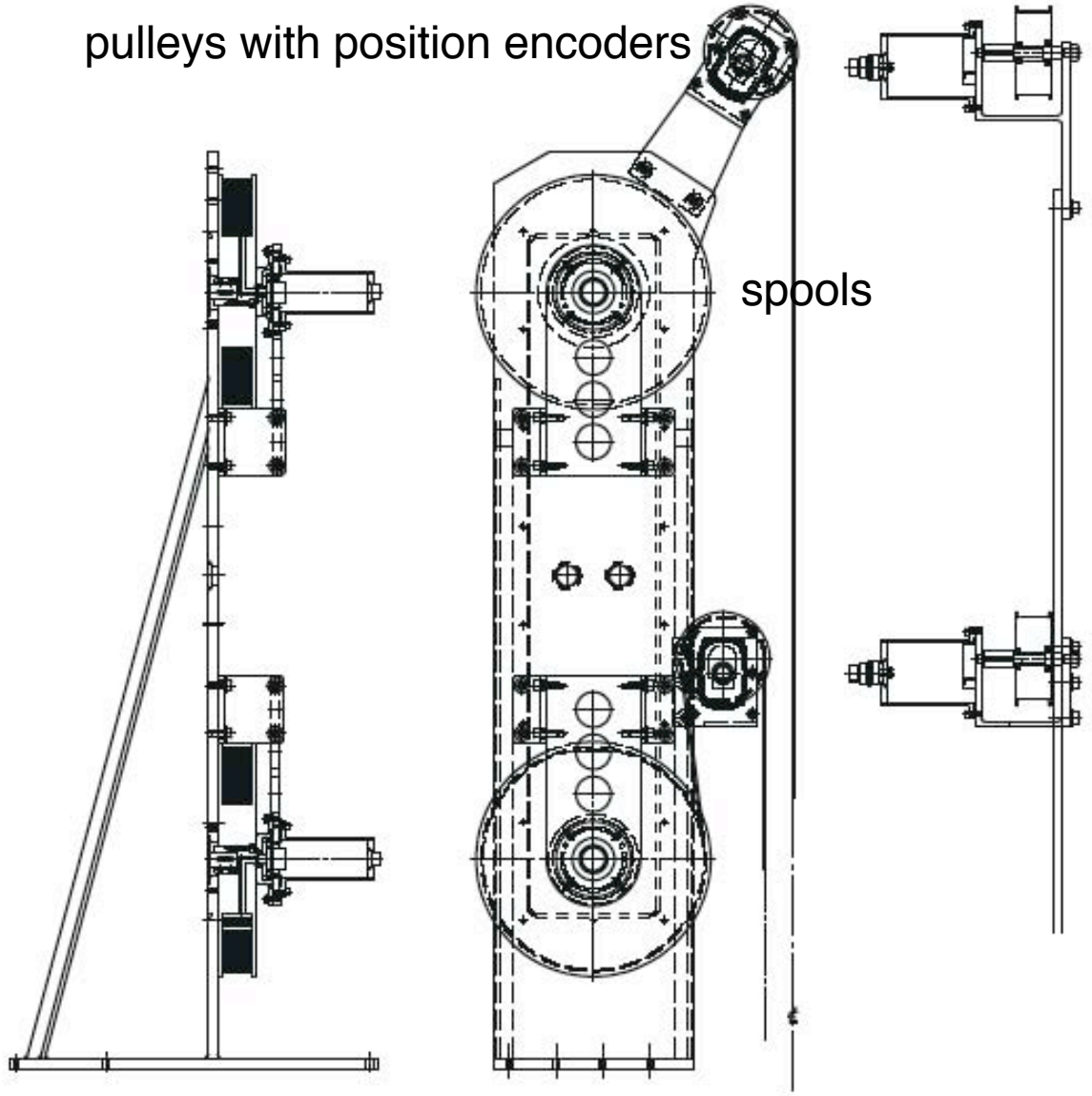
- Checked dimensions and bolt pattern.

- Investigated leaks in the glovebox.

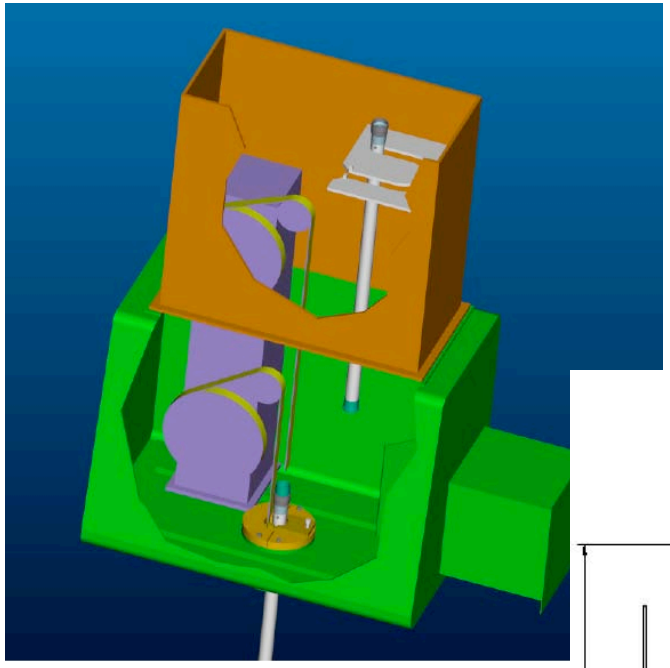


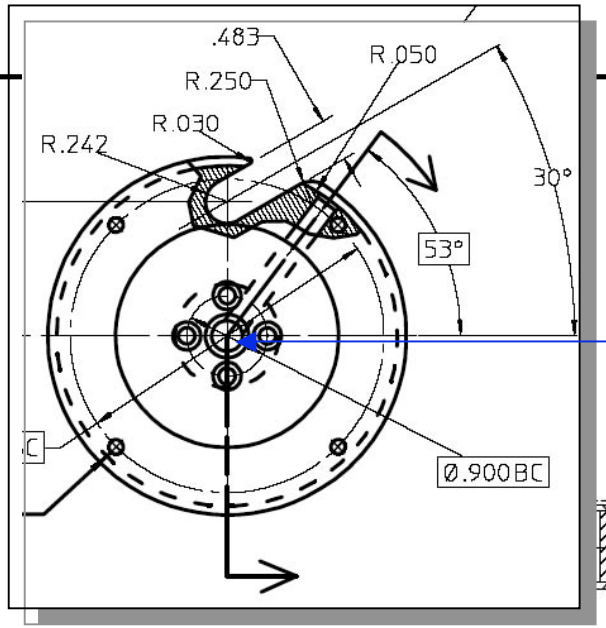
Motor Drive System



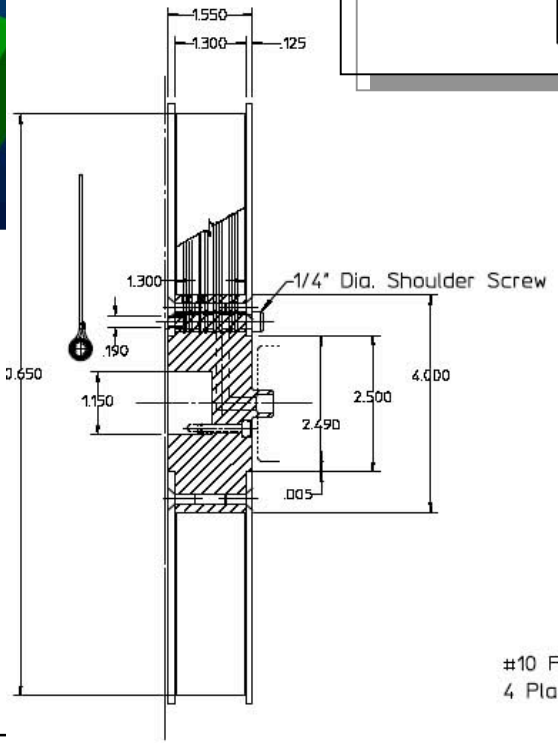


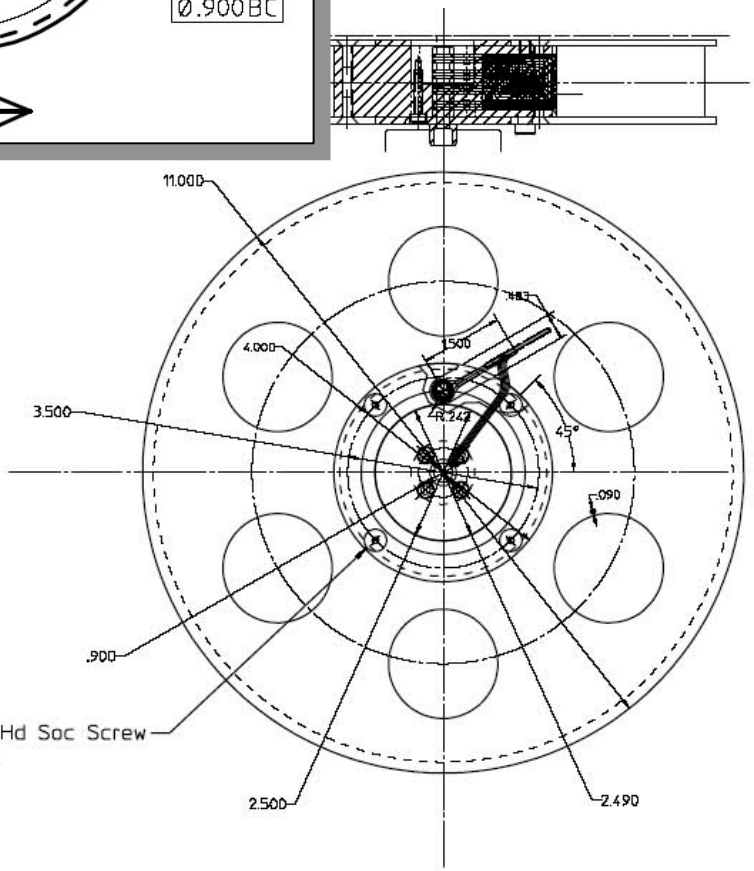
Spools



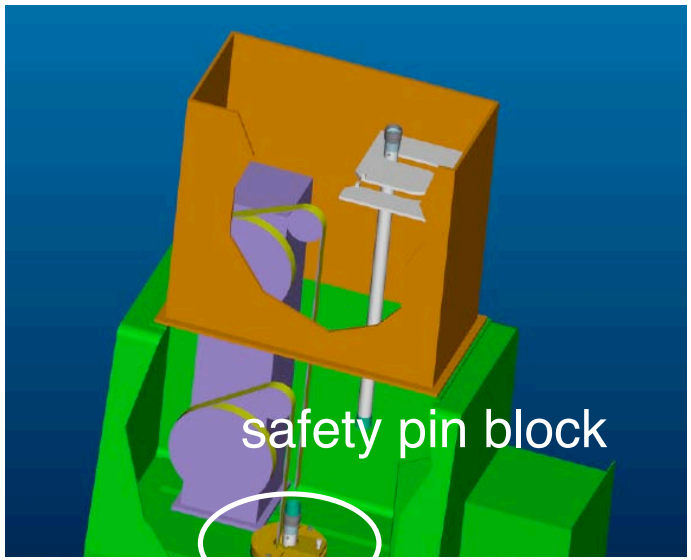


enclosed slip ring with electrical connections



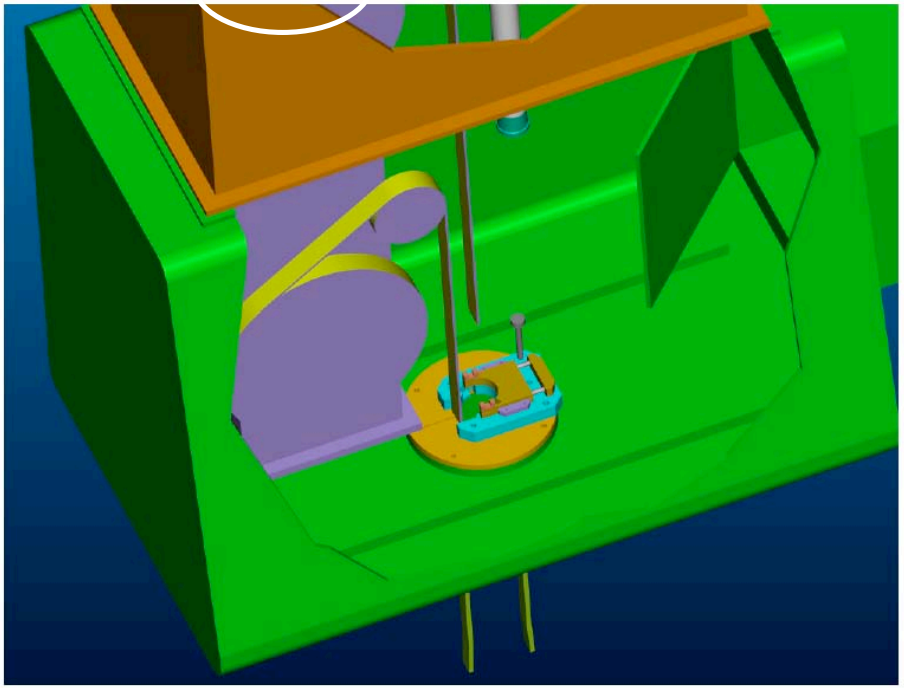


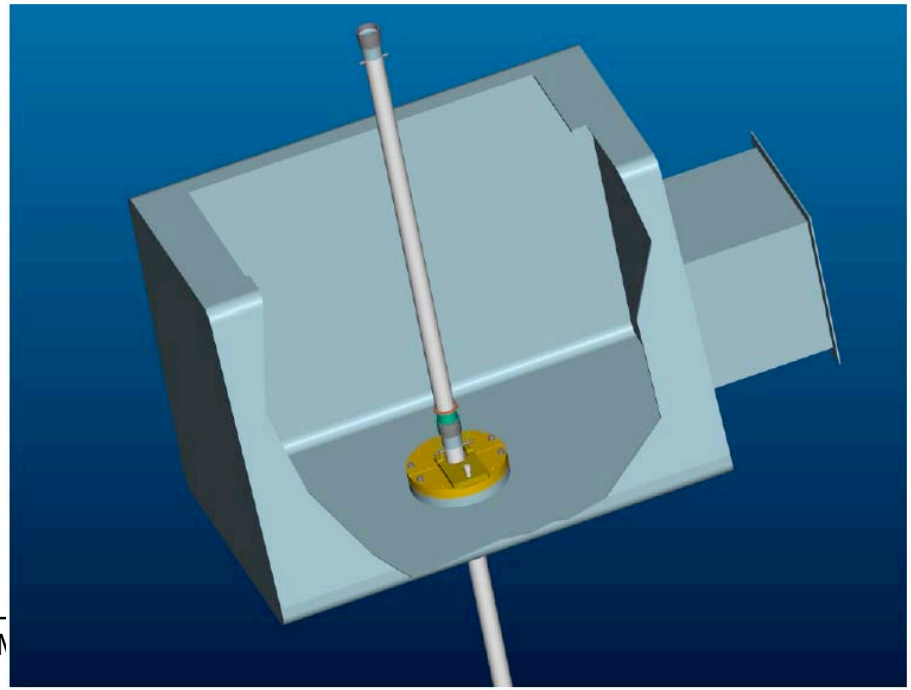
Safety Pin Block



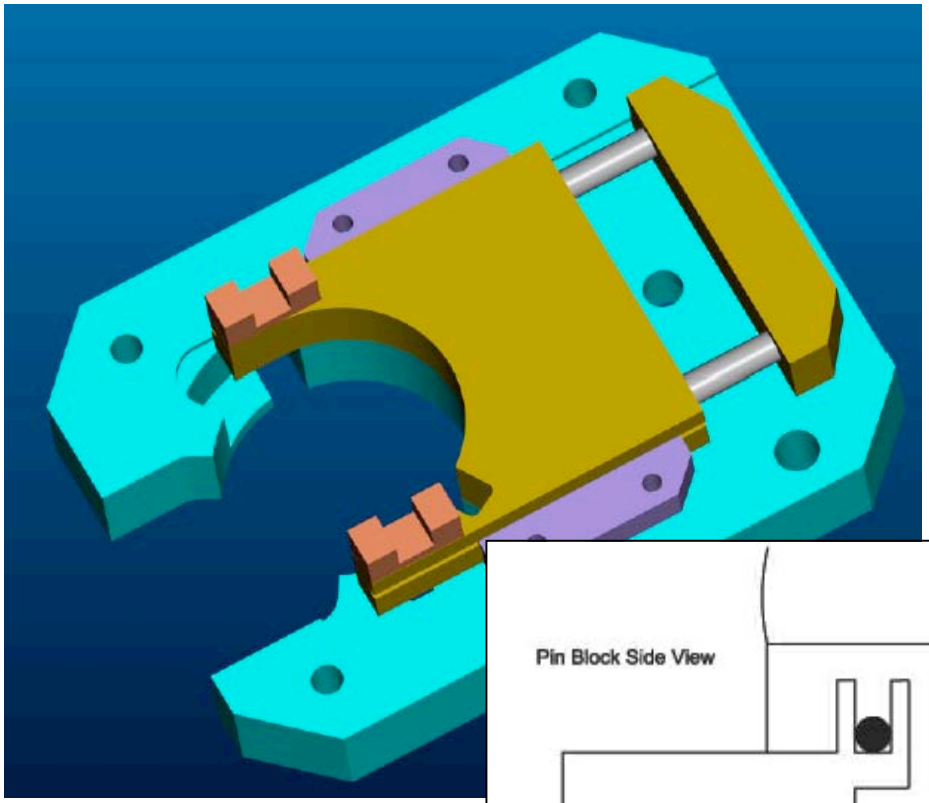
Purpose

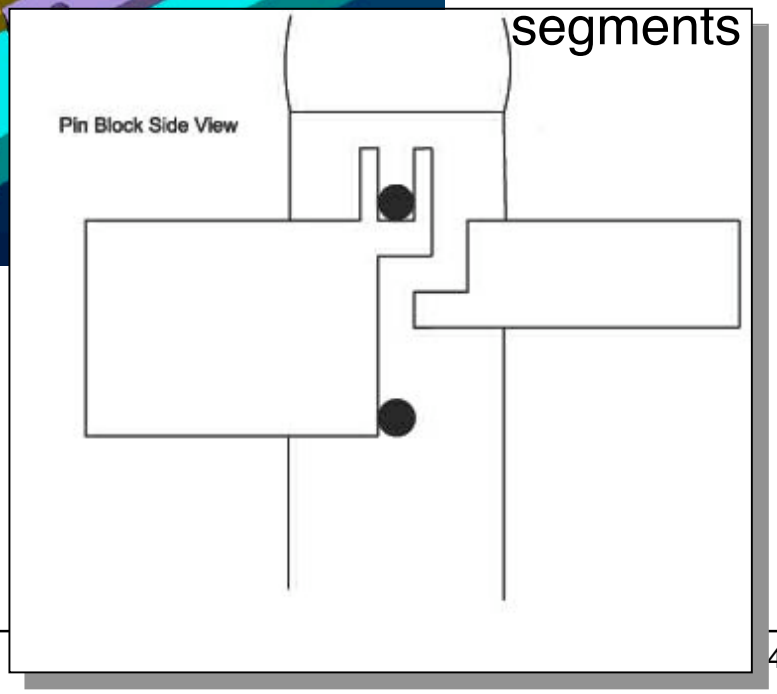
I. Safety block between glovebox and detector.
II. Used for assembly of pole.
III. Allows easy retrieval of pole.





Safety Pin Block



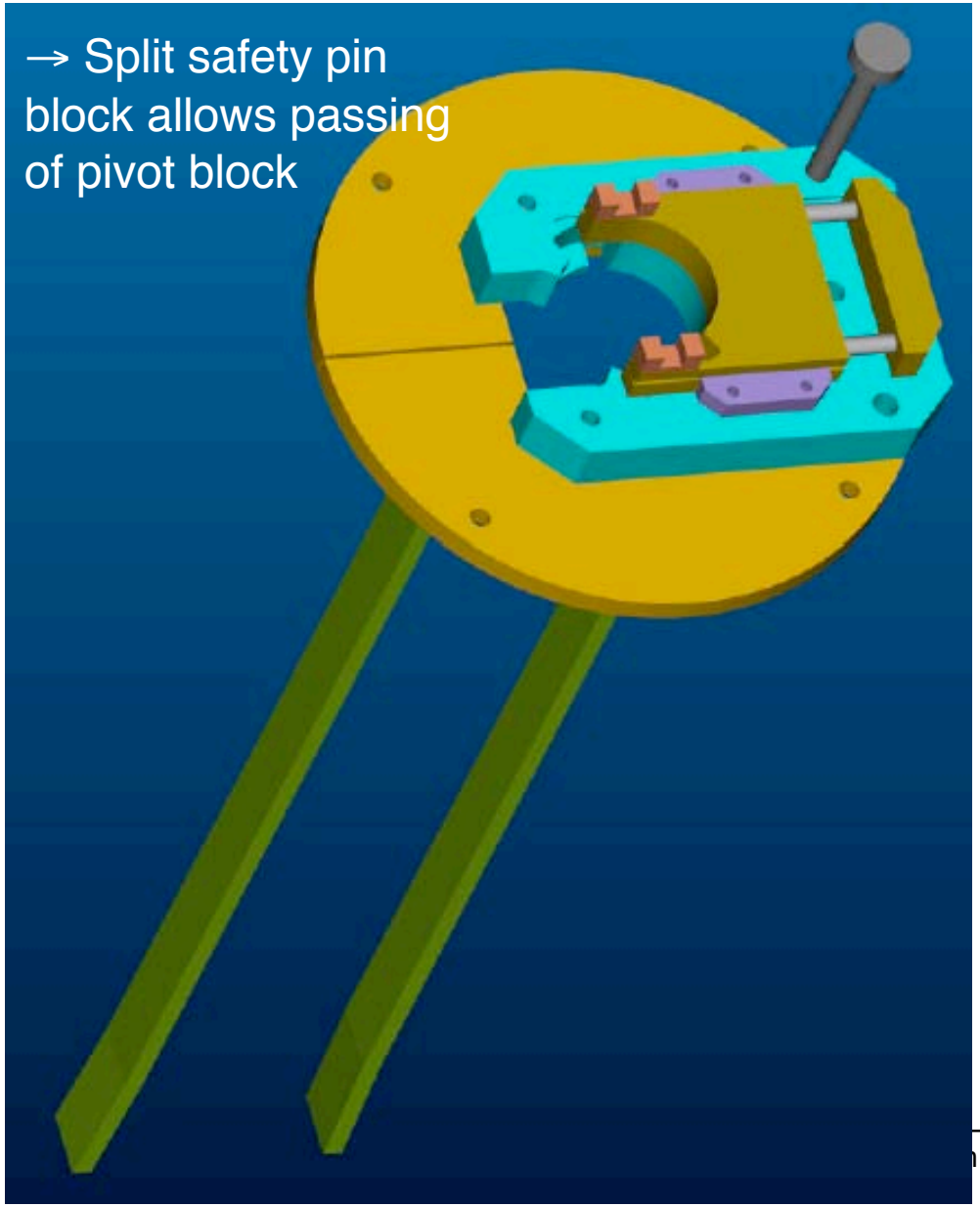


1. prevents pole segments from dropping into detector

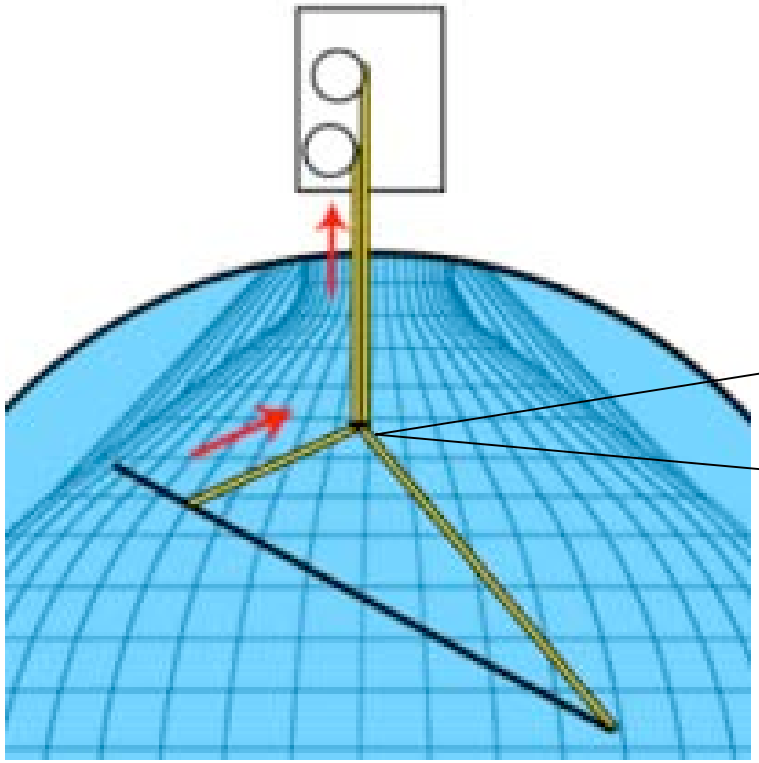
2. operator needs to turn pole segment when engaged in safety pin block

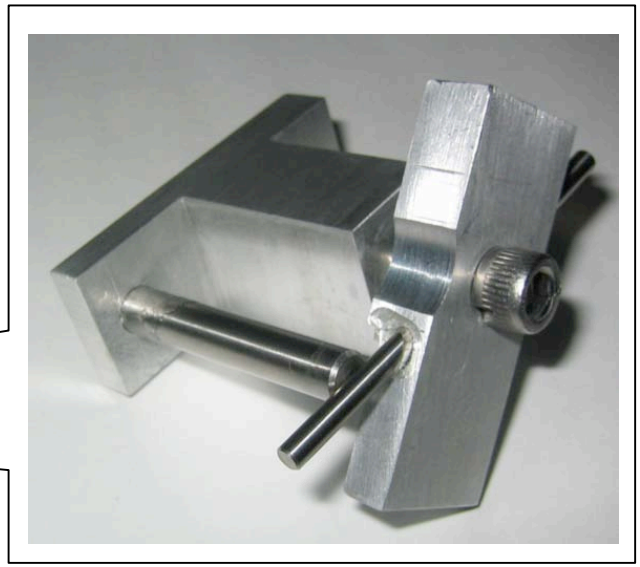
3. sliding block allows easy retrieval of calibration pole segments

Safety Pin Block



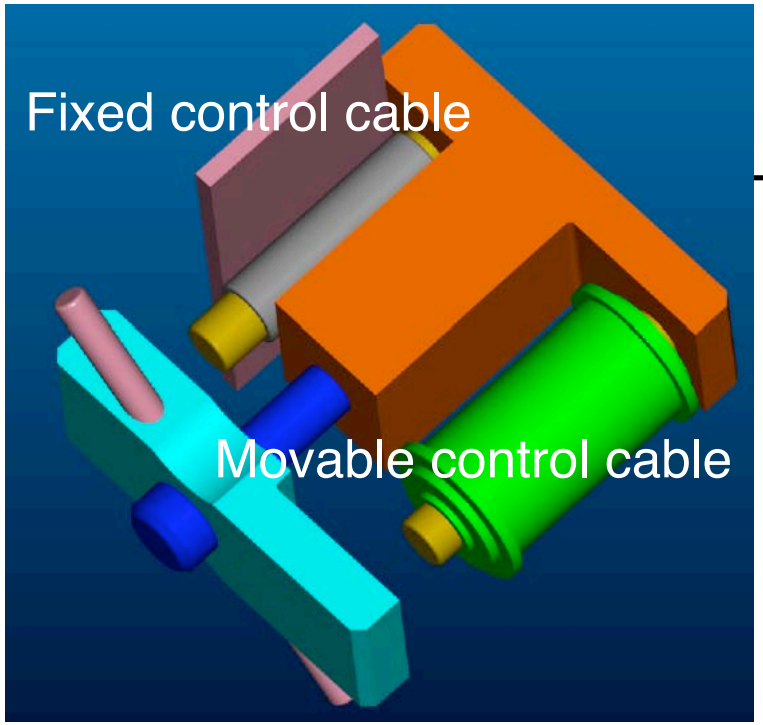
Pivot Block

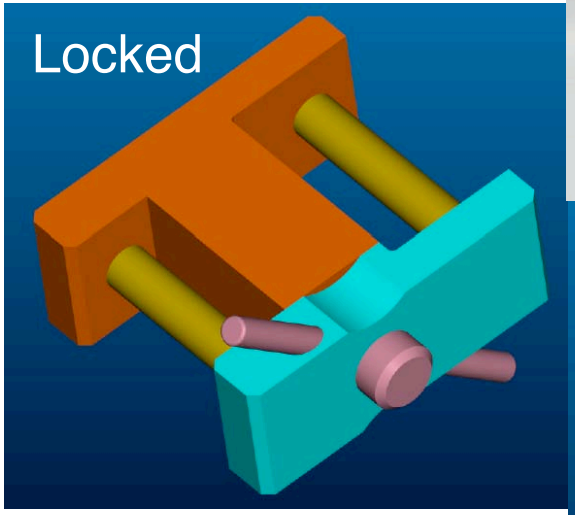




An essential part to control motion of system

Pivot Block


Fixed control cable
Movable control cable


Locked

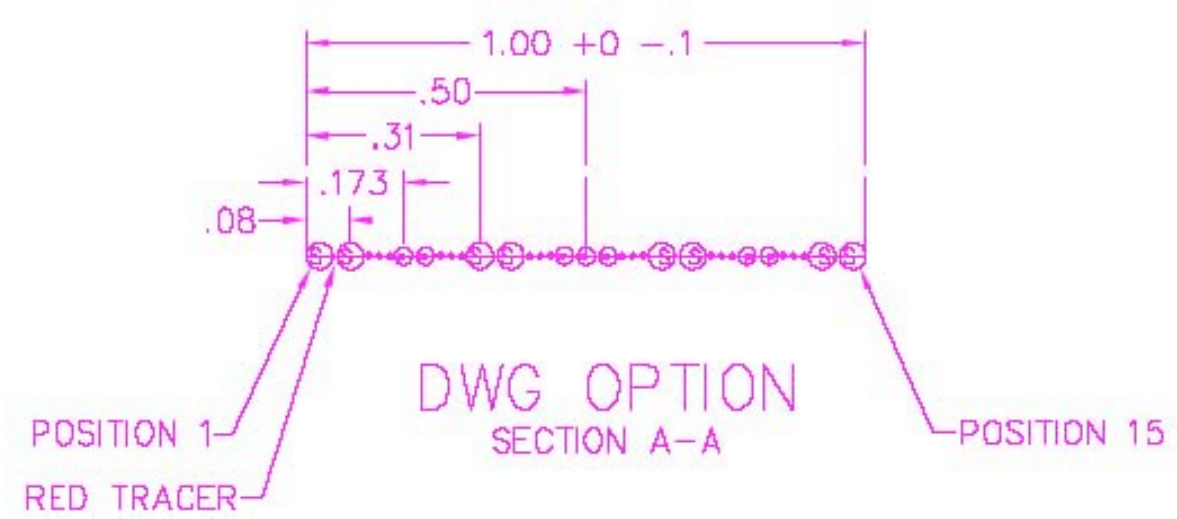

Disengaged

Control Cable

Woven cable with

- 8 load-bearing stainless steel cables
- 6 conductors

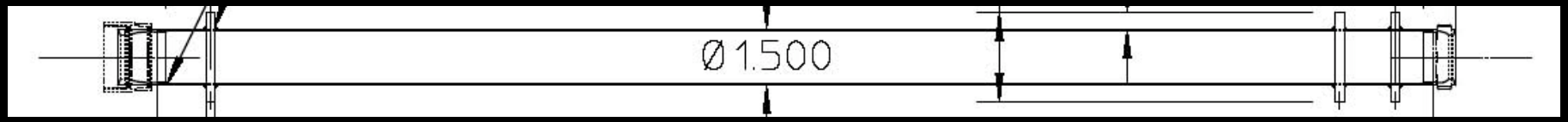
1. MATERIAL:
2. SS WIRE TO BE SUPPLIED BY CUSTOMER.
3. PVC INSULATED WIRE TO BE SUPPLIED BY CUSTOMER
4. DELETE
5. FILLERS AND BINDERS TO BE 1983 SA-FEP OR EQUIVILANT QTY. APPROX., AR TO MEET WIDTH.

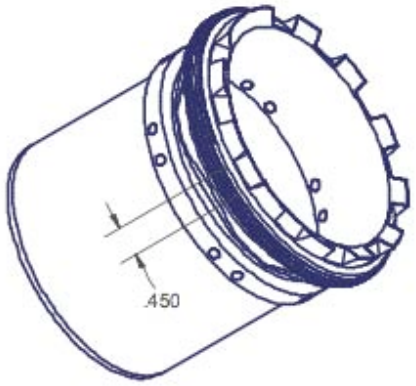


Calibration Pole

- 8 segments
- Each segment is 3’ long
- 1.5” titanium tubing (reduces weight and increase safety)
- Bicycle Torque Couplings (BTC) used to connect segments together
- .25” pins for deployment safety and for proper tightening of the couplings

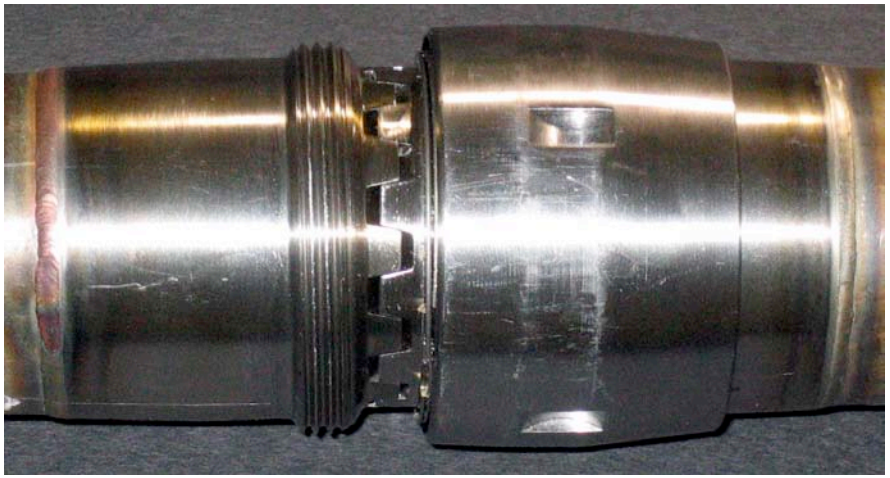
Pole Segment

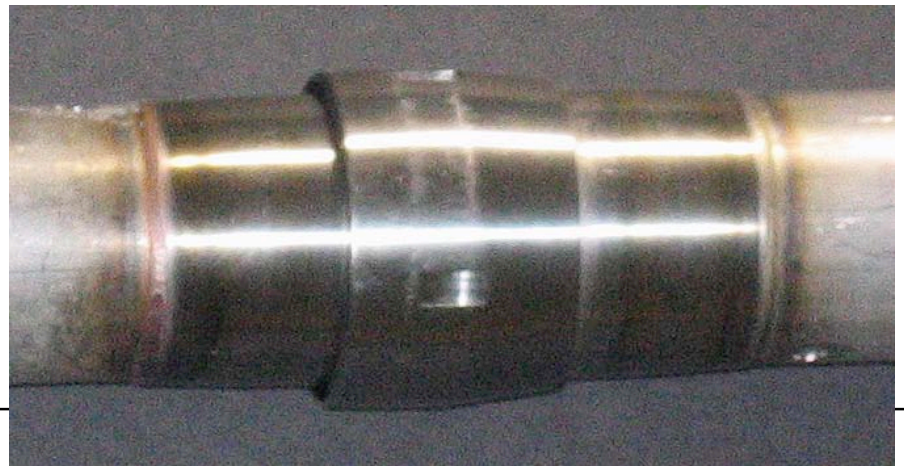




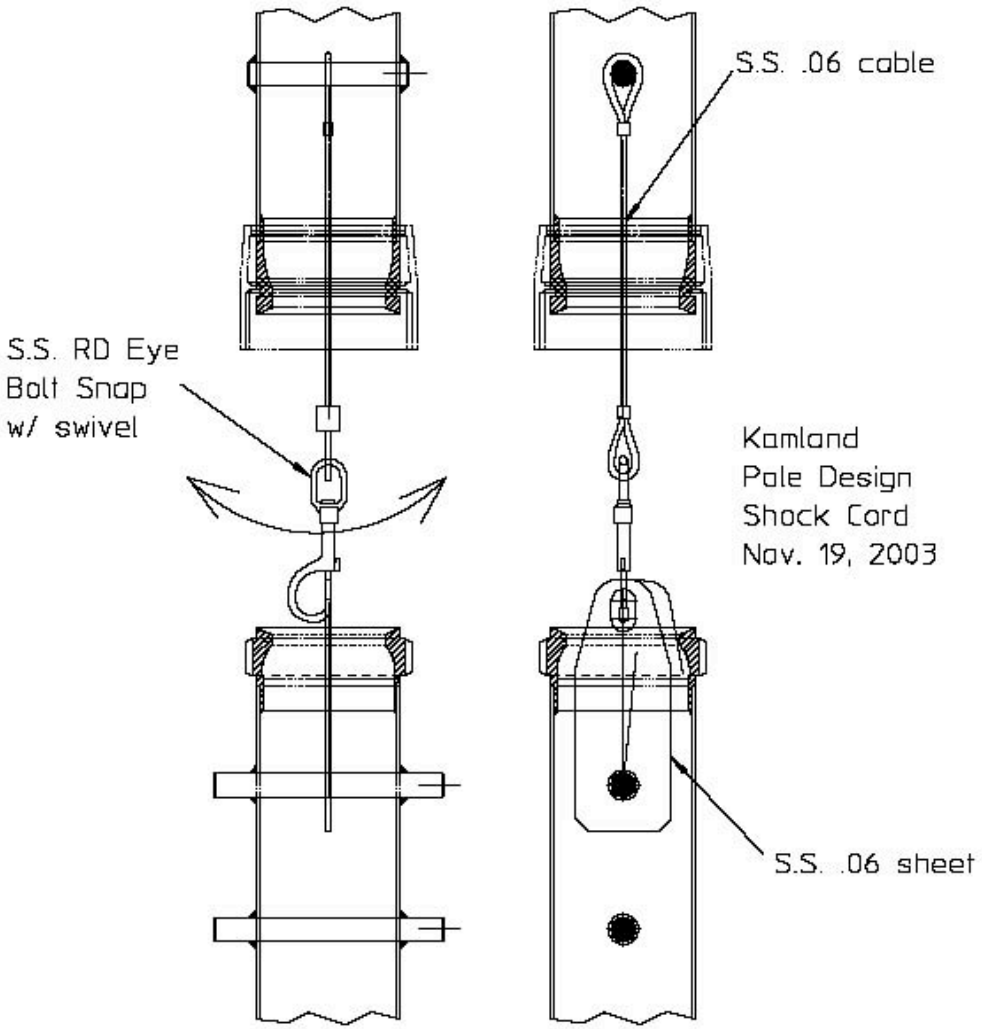
Bicycle Torque Coupling (BTC)

- Designed to combine tube segments
- Coupled with controlled torque
- Load rated

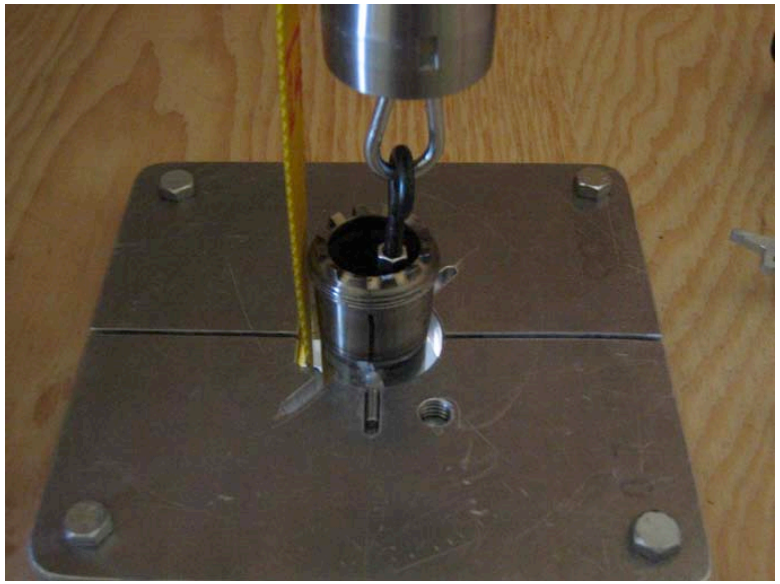




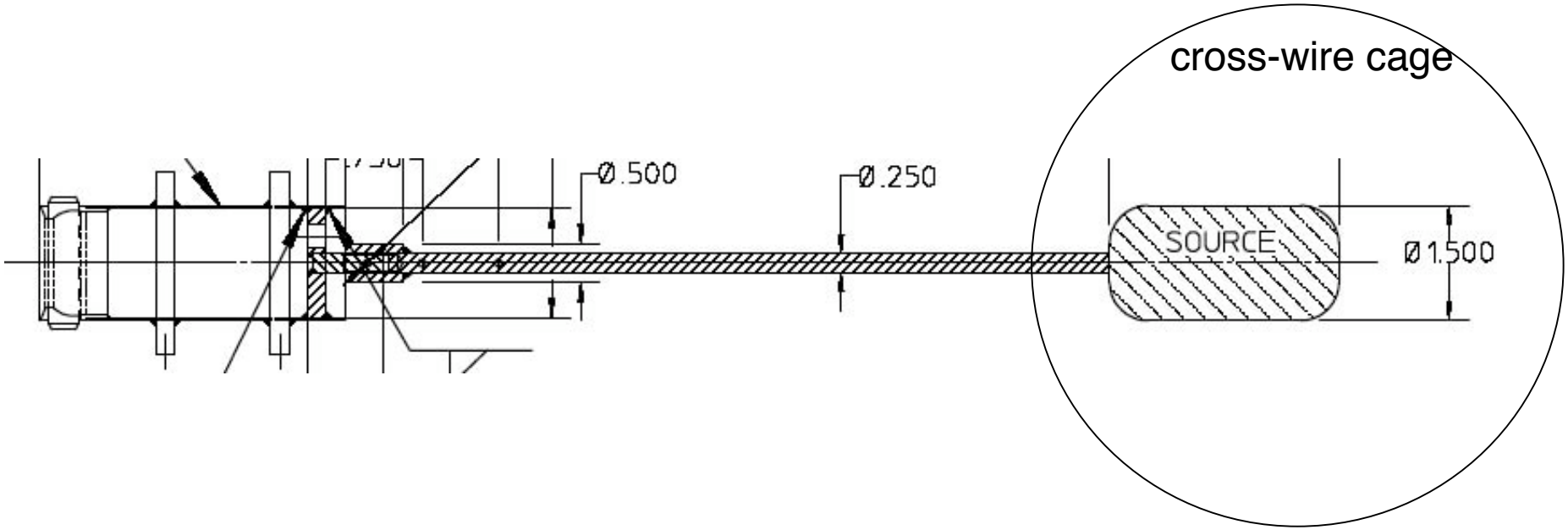
Internal Safety Line Between Pole Segments



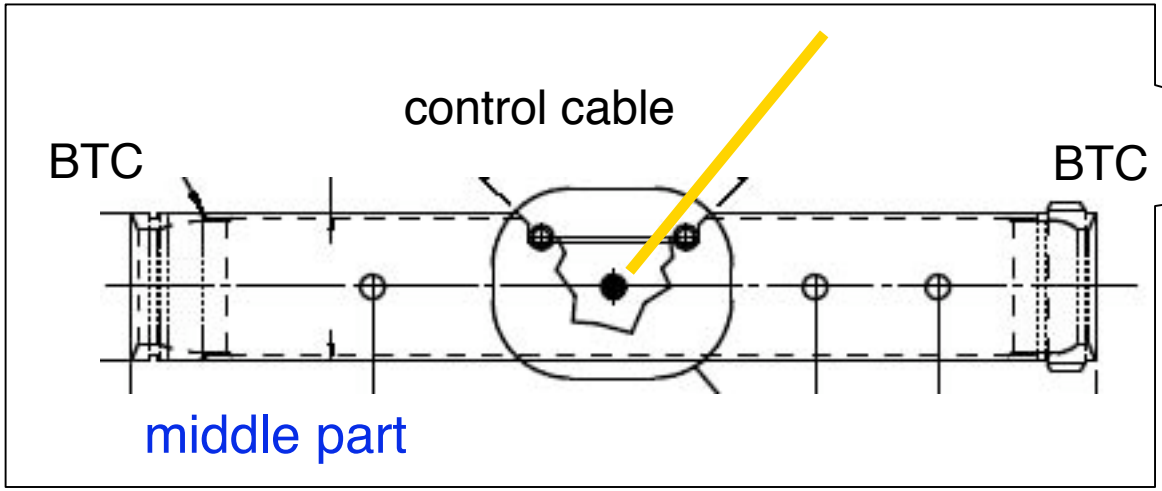
early prototype

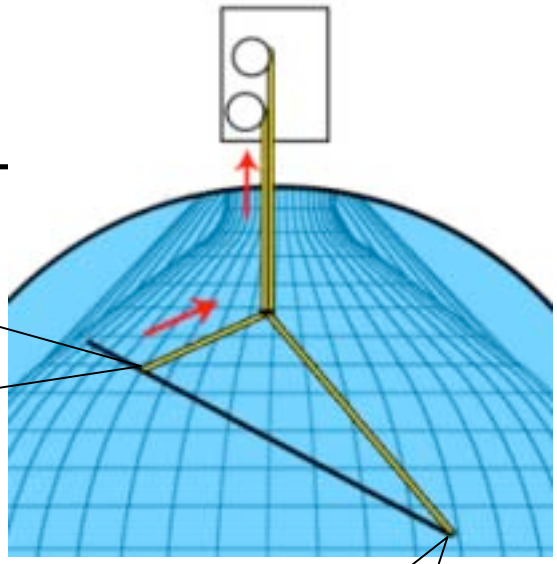


Source Mount

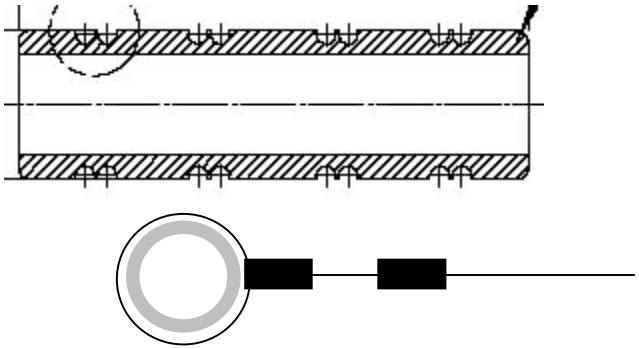


Cable Attachment to Pole

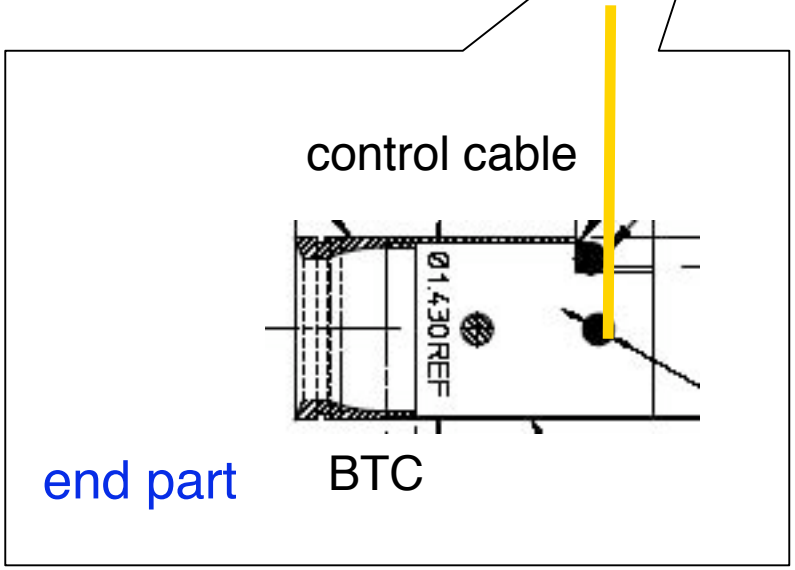




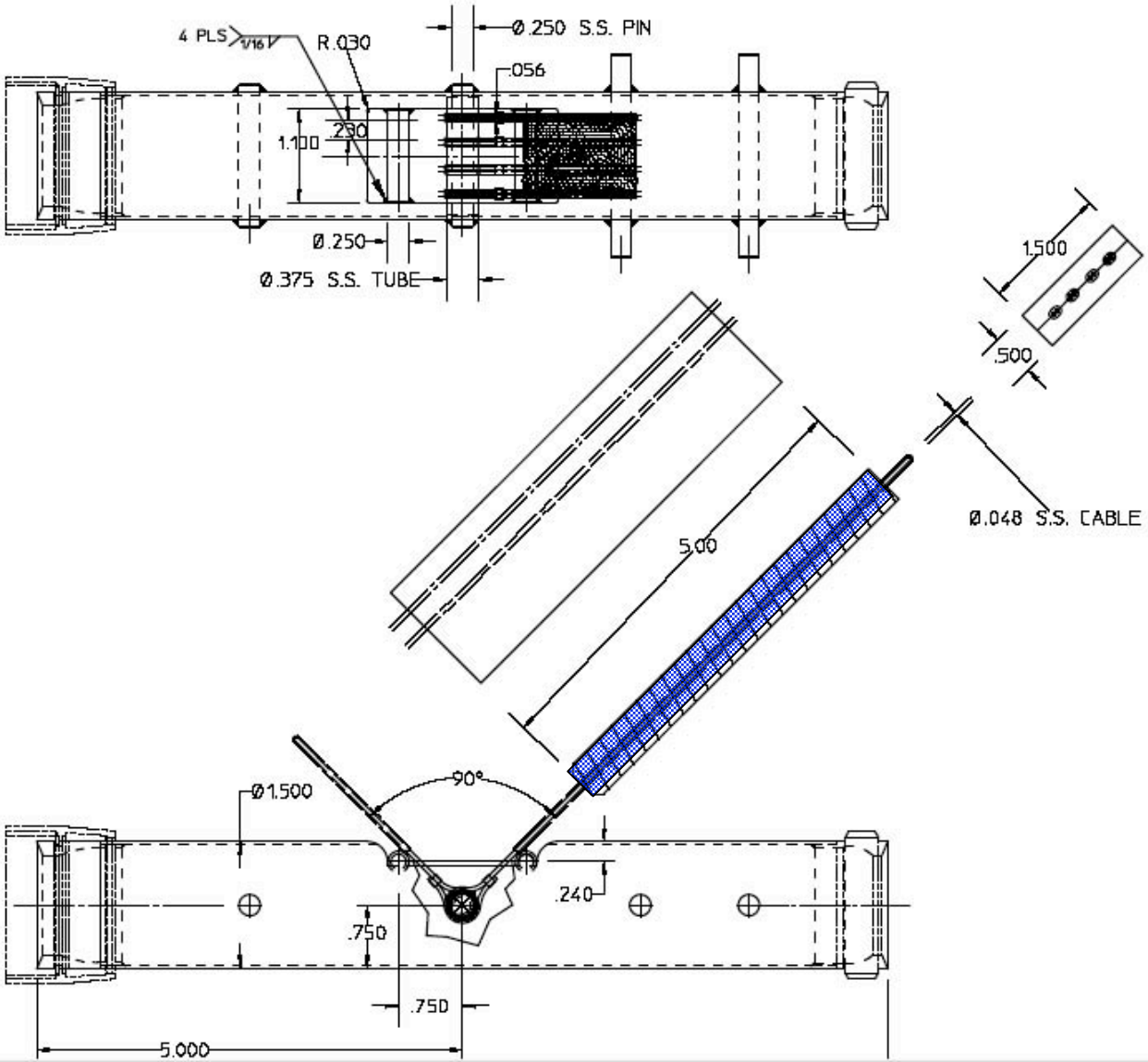
stainless steel cables will be crimbed around tube

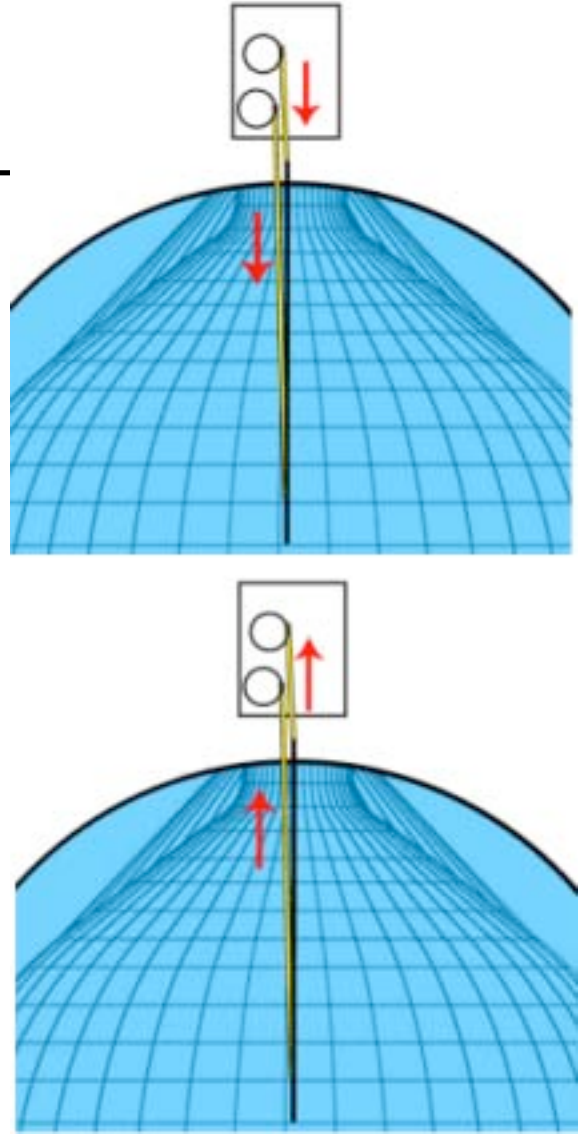


preliminary load tests > 100 lbs



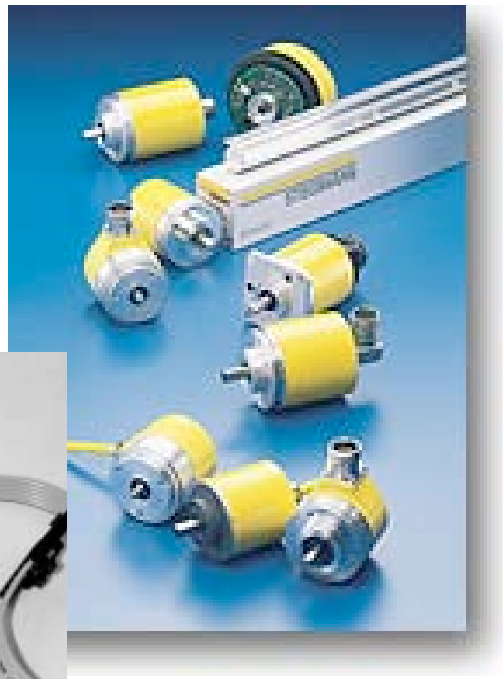
Cable Weight

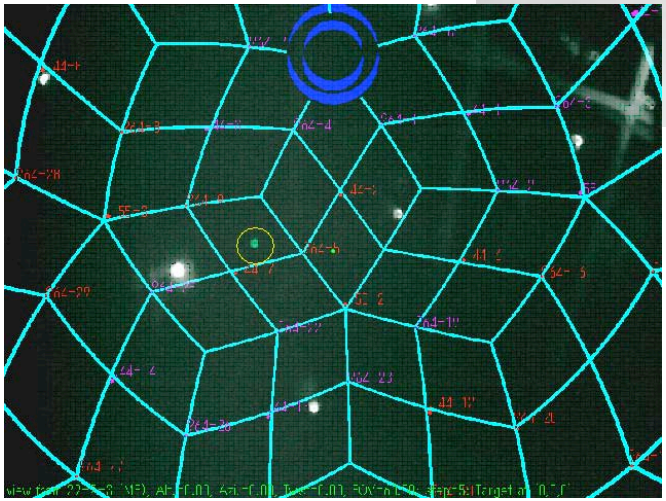




Instrumentation for Monitoring and Position Determination

1. Position Encoders √
2. Pressure Transducers *(being tested, readout under development)*
3. CCD Imaging of LEDs (*under development)*





Materials Qualifications

Principles and Guidelines

- All materials to be used in the detector are or will be tested.

- All new materials to be used in the glovebox are or will be tested.

- Samples from any material which may be radioactive will be tested as a specific batch out of production (eg. titanium from the specific batch of Ti from the pins, from the couplings, and from the segments will each be tested).

- Prior to testing and deployment, all materials and containers are being cleaned at LBNL, as per UHV standards
(details in document at http://kmheeger.lbl.gov/kamland/4pi/)

- Control samples of LS are prepared at the start of each soak.

Materials Testing

Degradation or Deterioration

• Soak test for visible degradation or deterioration of material (This has been done at LBNL for each material)

Optical Transparency

• LS from sample soak is compared against control sample using spectrophotometer in Mozumi

Radioactivity

- Portion of LS soak liquid will be counted for possible radioactive leaching

  Christopher, Evgueni offered to do counting on site.
- Materials resistive to acid will be wiped with weak Nitric solution and the acid counted.

  Christopher, Evgueni offered to do counting on site.
- If necessary, some actual parts can be counted (e.g. encased circuitry of pressure transducers)
- Remaining material samples from LBNL as parts come out of fabrication (shops will provide samples by March 30)

Installation, Commissioning, and Deployment Plan for the KamLAND Off-Axis Calibration System

Commissioning Plan

Phased Approach

- Safety first. Verifies functionality of system step-by-step.

- Minimize impact on regular data taking and on-site work.

- Obtain additional calibration data as early as safely possible for current analysis (verification) while continuing to optimize instrumentation of system (for independent volume determination)

Step I - Installation of Hardware

Goal: Installation of glovebox extension and deployment system.

Required Decisions Prior to Phase I (critical decision I)

→ Ready to start installation of 4pi hardware. Materials approval.

Data Taking & Calibrations

→ Can largely continue quality reactor neutrino data taking.
→ No z-axis calibrations possible.

Work Plan

- Closing gate valves.
- Lift glovebox and exchange of rotary stage. Seal and check stage afterwards
- Remove z-axis system.
- Open top of existing glovebox.
- Install new winch system.
- Clean glovebox and calibration tent.
- Install glovebox extension (penthouse).
- Seal new glovebox and leak test.
- Install drip pan, connect to 4 swage lock connectors
- Modify/connect N2 purge tubes.
- Purge glovebox.

4+2 days

Critical Personnel

Don Syversrud
Berkeley 4pi group

Step II - Final Hardware Tests and Certification

Goal: Final test and certification of installed hardware.

Required Decisions Prior to Phase II

→ None.

Data Taking & Calibrations

→ Can largely continue quality reactor neutrino data taking.
→ No z-axis calibrations possible.

Work Plan

- Monitor leakage of new glovebox.
- Test functionality of new hardware in glovebox.
- Have calibration experts and on-site coordinators review the installed hardware.
- Collaboration (or executive) decision that new hardware can be used.
- Report to collaboration.

2+1 days

Critical Personnel

Berkeley 4pi group
Calibration experts
On-site coordinators
Executive committee

Step III - Z-Axis Calibration with New Deployment Hardware

Goal: Demonstrate that z-axis calibrations can be performed with new deployment system (calibration and analysis).

Required Decisions Prior to Phase III (critical decision II)

→ Ready to use new deployment hardware.

Data Taking & Calibrations

→ Can largely continue quality reactor neutrino data taking.
→ Z-axis calibrations *possible* with new deployment system.

Work Plan

- Deploy standard calibration sources with new system.
- Analyze calibration data and compare to previous z-axis calibrations.
- Evaluate consistency of calibration data and backgrounds before, during, and after calibration.
- Report to collaboration.

} 3+3 days

Critical Personnel

Berkeley 4pi group
Calibration experts
Analysis groups

Step IV - First Symmetric Off-Axis Calibrations

Goal: First off-axis deployment of sources using short pole (eg. 2 segments).

Required Decisions Prior to Phase IV (critical decision III)

→ New z-axis calibrations found to be consistent with old z-axis calibrations.

Data Taking & Calibrations

→ Can largely continue quality reactor neutrino data taking.
→ First off-axis calibration data.

Work Plan

- Deploy standard calibration sources with short pole segment.
- Evaluate success or problems of first off-axis deployment.
- Report to collaboration.

} 2 days

Critical Personnel

Berkeley 4pi group
Calibration experts
On-site coordinators

Step V - Extended Symmetric Off-Axis Calibrations

Goal: Off-axis deployment of sources using multiple pole segments.

Required Decisions Prior to Phase IV

→ No problems found with first off-axis deployment.

Data Taking & Calibrations

→ Multiple off-axis deployments of sources.
→ Reduced livetime for reactor neutrino data taking.

Work Plan

- Deploy standard calibration sources with calibration pole of different lengths.
- Evaluate success or problems.
- Evaluate readiness and need to use counterweight.
- Report to collaboration.

} 5 days

Critical Personnel

Berkeley 4pi group
Calibration experts
On-site coordinators

Step VI - Asymmetric Off-Axis Calibrations

Goal: Asymmetric off-axis deployment of sources using multiple pole segments.

Required Decisions Prior to Phase IV

→ No problems found with extended symmetric off-axis deployment.

Data Taking & Calibrations

→ Multiple off-axis deployments of sources.
→ Reduced livetime for reactor neutrino data taking.

Work Plan

- Deploy standard calibration sources with calibration pole of different lengths and counterweight.
- Evaluate success or problems.
- Report to collaboration.

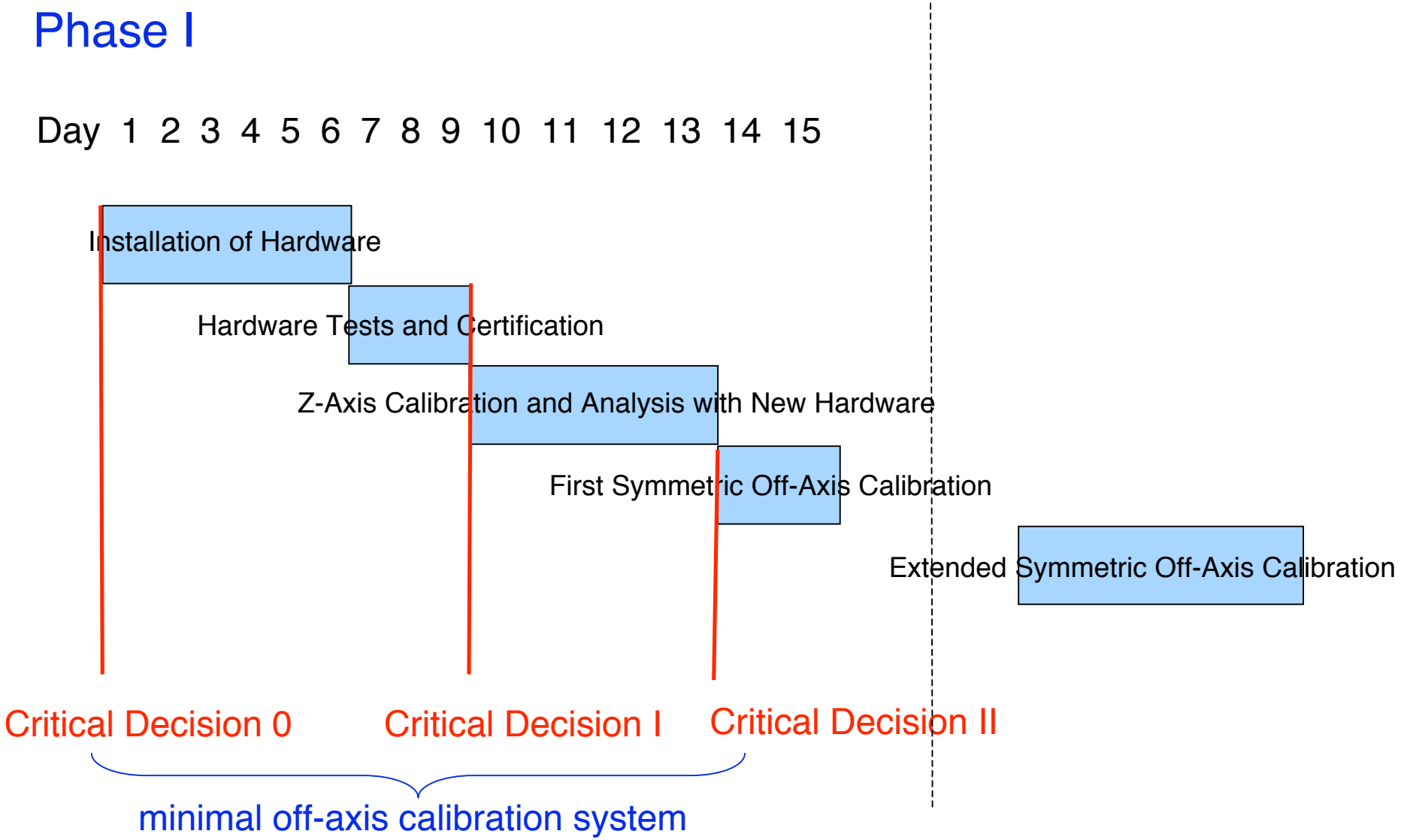
} 5 days

Critical Personnel

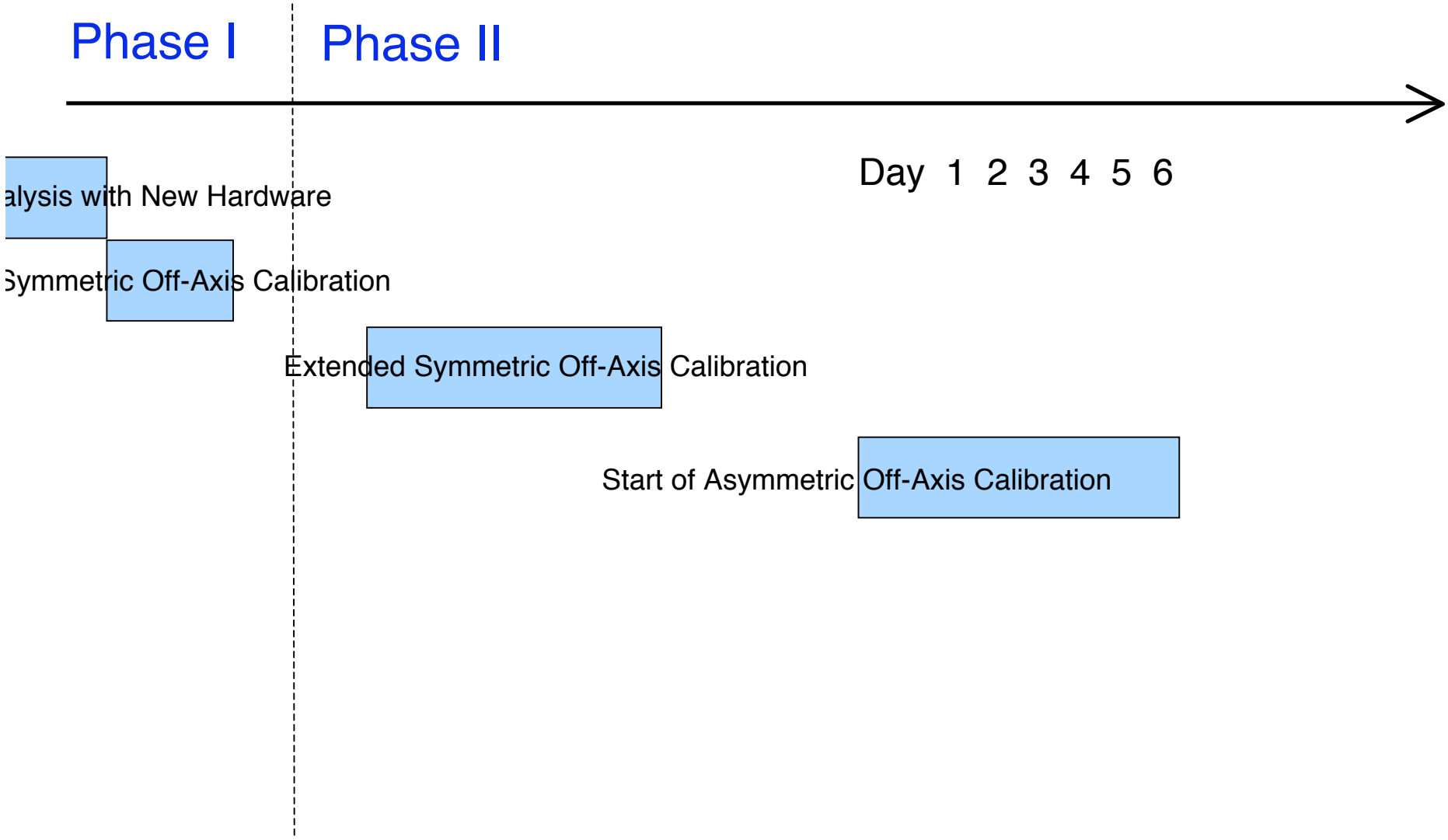
Berkeley 4pi group
Calibration experts
On-site coordinators

Commissioning Schedule

Phase I

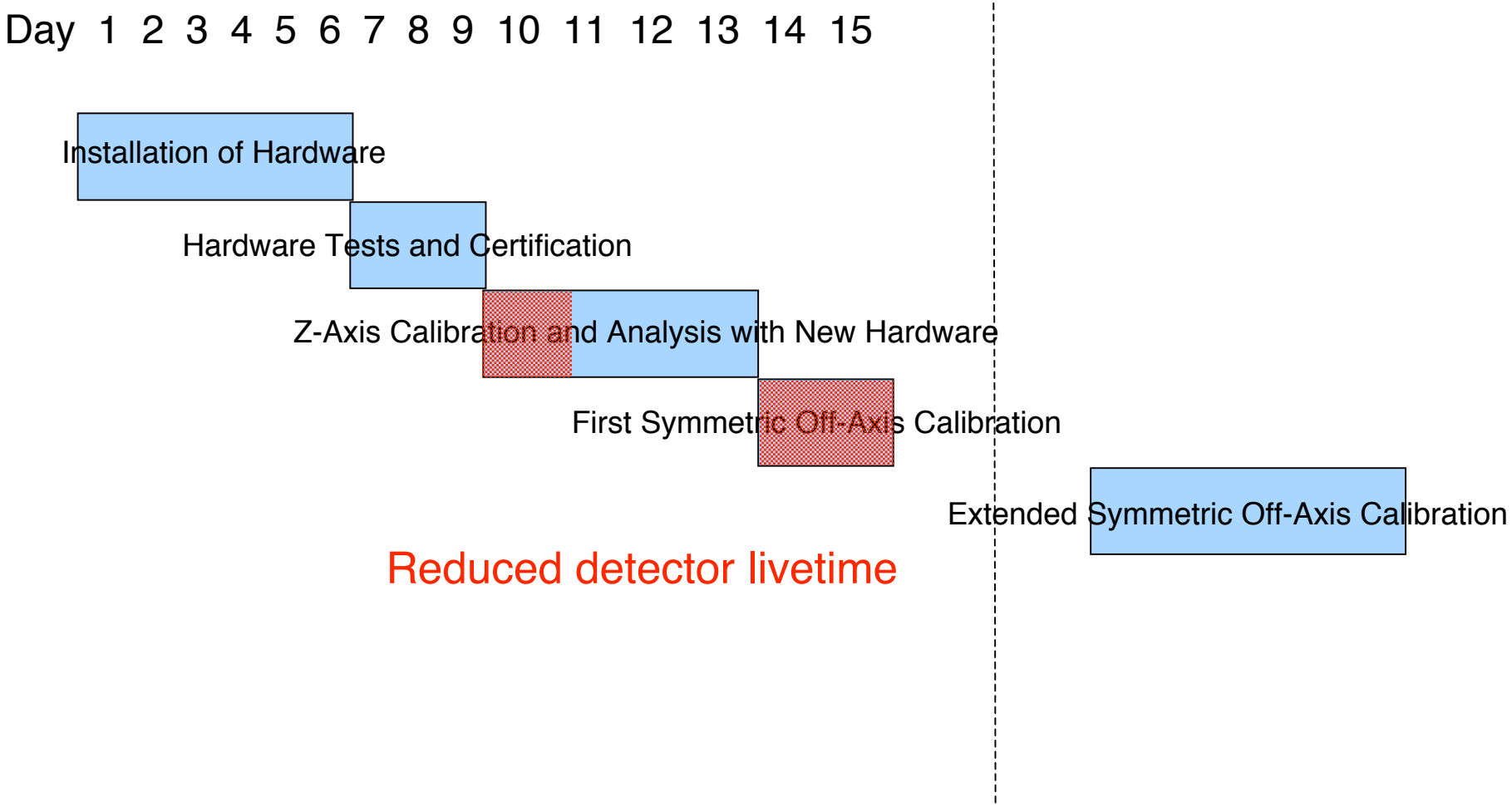


Commissioning Schedule



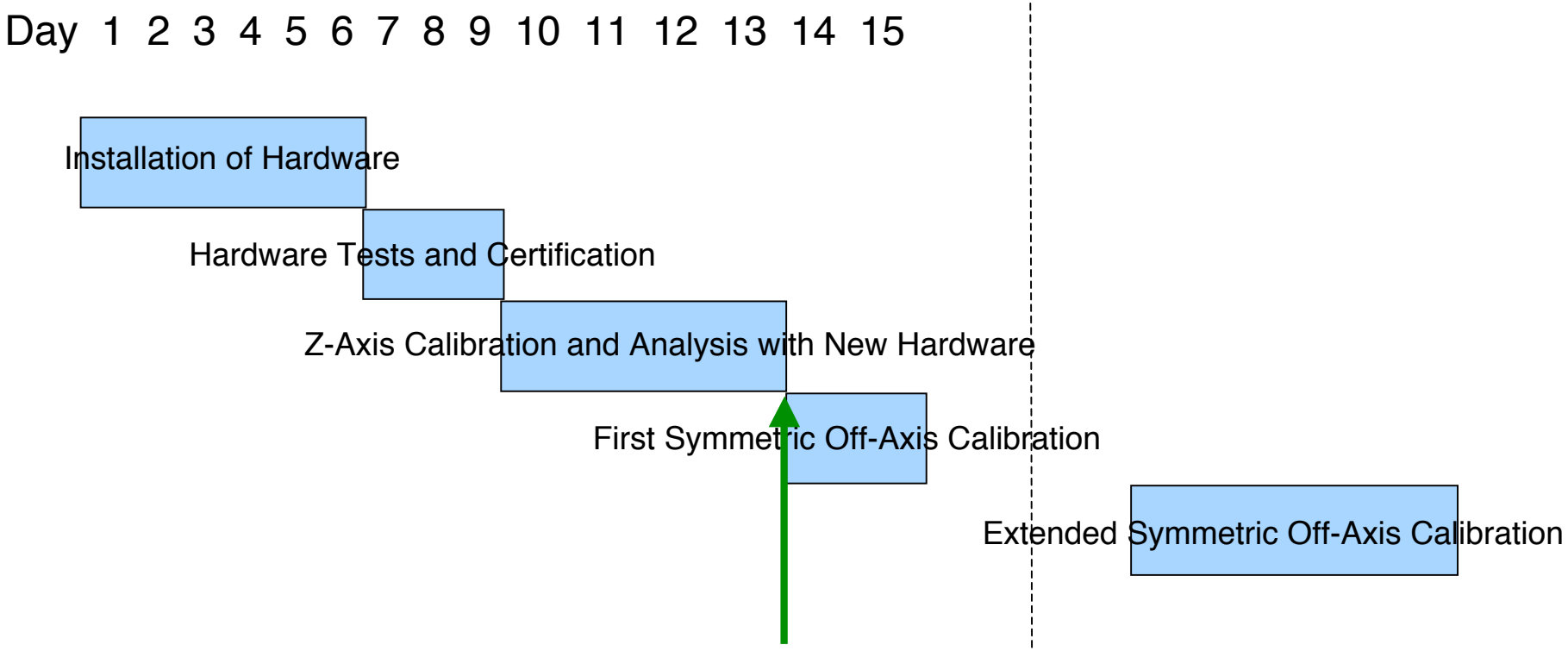
Commissioning Schedule

Phase I - Commissioning and Data Taking



Commissioning Schedule

Phase I - Physics Potential of Symmetric Off-Axis Calibrations

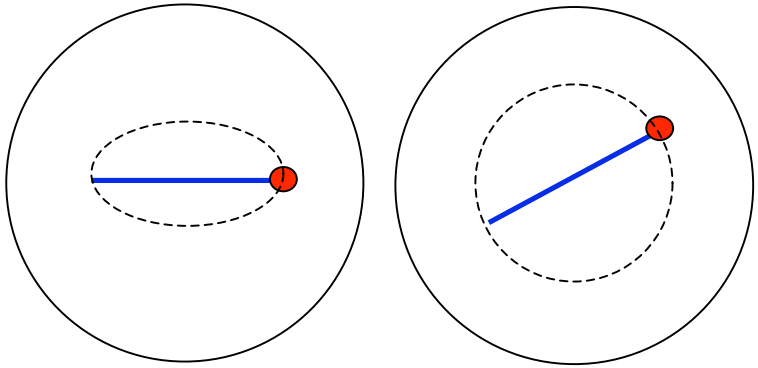


What can we learn from a deployment of the minimum off-axis calibration system?

Calibration with a minimum 4π system?

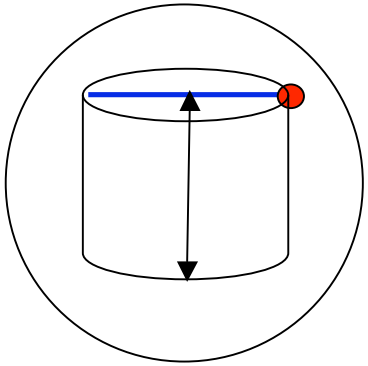
- *no counter weights*
- *primary position information from encoders*
- *pressure sensors on pole to verify horizontal position*

At Center



R=1, 2, 3, and 4 m
probe ϕ, θ symmetry

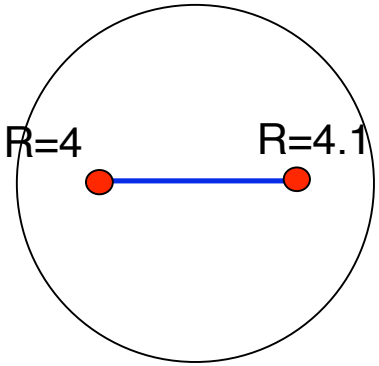
Along z-Axis



ρ = 1,2,3,4 m

R=R[z] < 6 m

With Two Sources

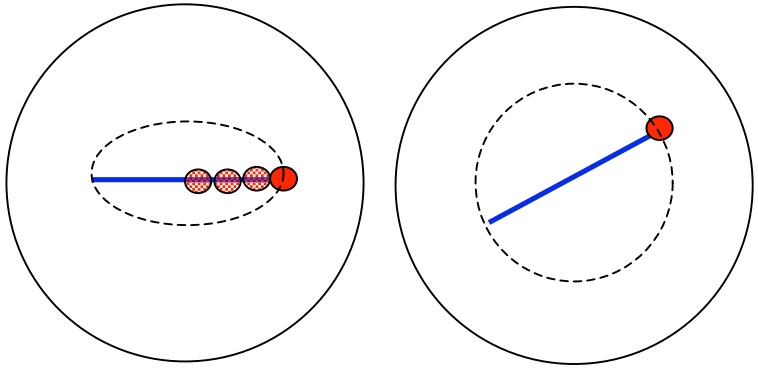


R=1, 2, 3, and 4 m
use symmetry of pole system

→ Minimum system may not give us enough data to derive systematic error independently but can provide cross-check of spallation distributions.

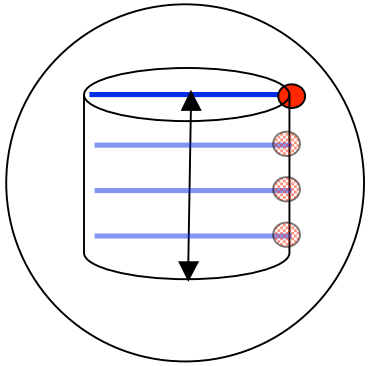
How would we analyze this data?

At Center



R=1, 2, 3, and 4 m
probe ϕ, θ symmetry

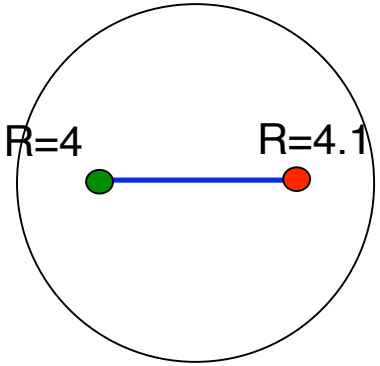
Along z-Axis



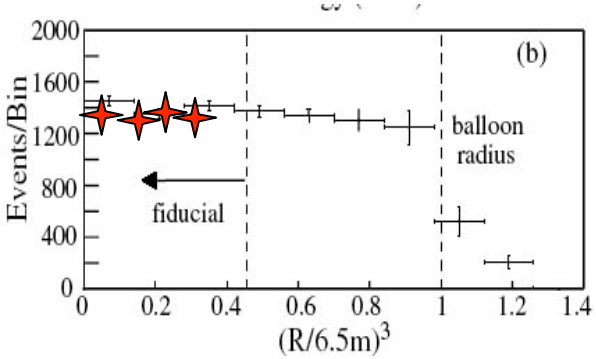
ρ = 1,2,3,4 m

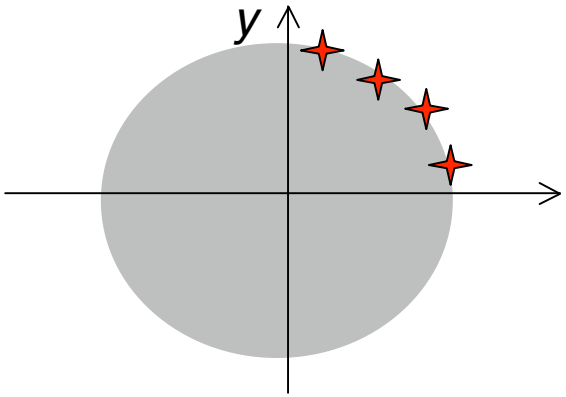
R=R[z] < 6 m

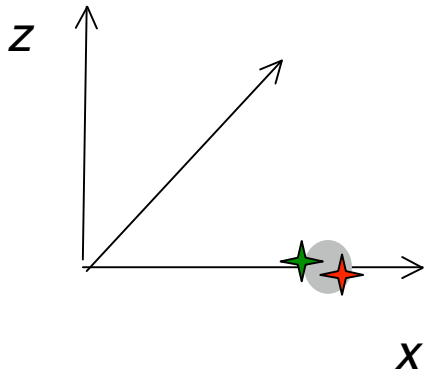
With Two Sources



R=1, 2, 3, and 4 m
use symmetry of pole system







Status and Schedule

March 2004	Complete fabrication of all parts
April 2004	Assembly, shakedown, and testing at Berkeley - will organize workshop for collaborators interested in testing system.
May 2004	Minimum system ready for installation - offline use of CCD images not optimized - partial use of instrumentation
July 2004	Full system ready for installation

Critical Steps

Testing period at Berkeley.

Counting of materials samples on site.

Schedule and Deployment

March 2004	Complete fabrication of all parts
April 2004	Assembly, shakedown, and testing at Berkeley
May 2004	Minimum system ready for installation
July 2004	Full system ready for installation

When should we deploy? (*some points for discussion*)

- *Not while we write a paper or finish analysis. Before or afterwards.*
- *Can we resolve the outstanding analysis issues and questions with further analysis of existing data?*
- *What can we do to get the calibration data we need to finalize current analysis?*

Schedule and Deployment

March 2004	Complete fabrication of all parts
April 2004	Assembly, shakedown, and testing at Berkeley
May 2004	Minimum system ready for installation
July 2004	Full system ready for installation

Would it help current analysis to have first set of off-axis data?

• Data from minimum off-axis calibration system may provide us with *verification* of spallation distributions, fiducial volume systematics, and energy dependence.

• Will require *concerted effort* to deploy system on a timescale that will aid the current analysis.